PROCEEDINGS

OF THE

ENGINEERS' CLUB

OF

PHILADELPHIA.

ORGANIZED, 1877.

VOL. VIII.

1122 GIRARD ST., PHILADELPHIA, PA.
PUBLISHED BY THE CLUB.
1891.

INDEX.

NOTE.—Papers, Notes and Communications, published in this Volume by title only, are not indexed by *subjects*, but under name of *author* only.

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ENGINEERS' CLUB OF PHILADELPHIA.

ORGANIZED DECEMBER 17th, 1877.

Vol. VIII.] JANUARY, 1891. [No. 1.

I.

SPIRALLY WELDED TUBES.

By GEORGE BURNHAM, JR., Active Member of the Club.

Read December 7th, 1889.

A WRITER upon sanitary matters has called attention to a certain horizontality characteristic of modern city life, as compared with the greater up-and-downness or verticality of primitive, and more especially agricultural, communities. In the latter, man raises his food from the ground at his feet, and obtains his drinking water from wells, springs and streams, close by his threshold, while his waste products are returned directly to the soil from which they came. In modern cities, however, food and drink must be brought horizontally from great distances, and, conversely, sewage and waste products must be conveyed to a distance to render them harmless. An incidental result of this change from the vertical to the horizontal mode of life, caused by the gathering of men into great cities, has been an enormous demand for pipes and tubes of all descriptions, not only to bring our water in and take our sewage away, as our sanitary friend has pointed out, but to convey to us our very light in the form of

illuminating gas, and our fuel in those favored regions supplied with natural gas. I believe the day is not far distant when it will be found more economical to pipe all our fuel, as gas, to the place of consumption, rather than to carry it there in the form of coal; or at least to effect its distribution within the cities in this manner. Already, in some of our cities, steam for both heat and power is thus distributed.

I wish to call your attention to-night, as engineers, to an interesting departure in the manufacture of this useful article. I refer to the steel pressure pipe manufactured by The Spiral Weld Tube Co., of East Orange, N. J., of which you have a specimen before you. These pipes are made by winding a ribbon of steel or iron spirally, and hammer-welding the overlapping edges. They are of any desired weight of metal, from No. 29 B. W. G. up to No. 8 B. W. G.; are hammer-welded along the entire length of the helical seam, and are probably the strongest pipes in proportion to weight ever made.

The advantages of winding the stock spirally in the case of iron pipe are evident, as it is well known that the greatest strength of rolled iron lies in the direction of the grain. Lap-welded boiler tubes, for example, are often "safe ended" to prevent splitting of the tubes in setting, the safe ends being merely short pieces of tube made with the grain running around the pipe, which are welded on to the tube proper. Steel, being homogeneous, is as strong one way as the other; but with either metal the helical weld acts as a strengthening band, instead of forming a line of structural weakness as in all butt-welded and most lap-welded pipe. Spirally welded tubes, however, are hardly to be classed as competitors with lap-welded tubes, as they are not made at all in the smaller diameters, their inferior limit being practically 6 inches. On the other hand, lap-welded pipes above 6 or 8 inches diameter increase rapidly in cost and difficulty of manufacture, as the stock used must be proportioned, not to the required strength of the pipe, but to the necessities of the process. Since the entire body of the pipe in the lap-welded process must be heated to a welding heat, light stock could not be used at all, as it would collapse and prove unmanageable. Consequently, pipes intended to carry large volumes of fluids at light pressures

often present the anomaly of say 75 lbs. of metal introduced solely to enable the pipe to be made at all, while 25 lbs. of metal do all the work. The new pipes may hence be said to cover a hitherto unoccupied or imperfectly occupied field.

The manufacture of spirally welded pipe is accomplished by automatic machinery. The skelp is passed into the machine, cold, from a guide table set at the desired angle. It is then fed forward to the "former," which bends it to the desired curvature. On its way to the forming jaws the anterior edge passes through a blow-pipe flame of fuel gas and air, meeting at the focus of the flame and overlapping the posterior edge of the preceding spiral. The edges are here united by the action of a light hammer striking about 160 blows per minute, the metal being sustained by an anvil block within the pipe. The normal product of a machine is about one foot of pipe per minute, receiving the stock cold and delivering its product cold. For long pipes it is necessary to cross-weld the skelp into continuous bands. This is done by automatic machines which unite the ends of the metal by straight lap-welds. The only limit to the length of a pipe, without joint, that may be thus made is that imposed by the conditions of economical transportation. As evidencing at once the length of pipe that can be made and the remarkable stiffness of the product, I have seen a single piece of 10-inch pipe, 40 feet long, supported on trestles near the ends and bearing the weight of three men without perceptible deflection. The stock used was No. 14 B. W. G.

The question as to the durability of this pipe, that is, its ability to withstand corrosion, will at once occur to the engineer. As to this, much will depend upon the character of the protective coating applied to the pipe, and upon the conditions under which it is used. We have not had sufficient experience in the East with light riveted pipes to determine this question, but upon the Pacific coast they have been largely used, and apparently have given little trouble upon this score. Mr. Hamilton Smith, Jr., in a paper read before the British Iron and Steel Institute, says: "So far as rust is concerned, in my extensive experience I have only seen one notable instance where an asphaltum coating properly applied did not protect the iron, and that was with a

pipe over which a stream of water highly charged with sulphate of iron passed. For a period of twenty years an asphaltum coating has prevented rust and also the formation of interior tubercles where soft water flows through the pipe."

After a section of the required length has been formed and welded on the machine, the ends are cut square and the pipe is tested by hydraulic pressure. Diameters under 16 inches are tested to 300 lbs. per square inch, larger diameters to 200 lbs. per square inch. The pipes never fail under this test, even in the case of light gauges and large diameters, the chief value of the trial being to develop leaks due to imperfect welding or defective spots in the stock. The couplings usually employed are the flange coupling with bolts, the cast-iron hub and spigot, and a locking sleeve, though a number of special couplings for special uses have been devised. In the first-named coupling, a cast or wrought-iron flanged collar, provided with the proper bolt holes, is passed over the pipe. The pipe end is then expanded and laid flat against the face of the flange. The joint is made by bringing pipe to pipe, with the intervention of a gasket suited to the use to which the pipe is to be put, and is entirely independent of the fit of the flange collars, whose sole office is to hold the flanged ends of the pipes together. Flanges are also attached to the pipe ends, rigidly.

The following tables, taken from the company's catalogues, indicate (table 1) the sizes of pipe manufactured, the theoretical strength for internal pressures, and (table 2) the comparative weights of spirally welded steel, lap-welded iron, and cast iron pipes, of equal diameters. I have not verified the figures, but have no doubt of their correctness:

TABLE No. 1.

Proof strength of stock, 40,000 lbs. per square inch.
Ultimate " " 65,000 " " "

Thickness B. W. G.	Diam. Pipe.	Grade.	Proof strength per square in.	Ultimate strength per square in.
18		Light.	653	1,062
16	6	Standard.	866	1,408
14		Heavy.	1,106	1,798
18		Light.	490	796
16	8	Standard.	650	1,056
14		Heavy.	830	1,349
16		Light.	520	845
14	10	Standard.	664	1,079
12		Heavy.	872	1,417
16		Light.	433	704
14	12	Standard.	553	899
12		Heavy.	727	1,181
10		Ex. heavy.	893	1,451
16		Light.	371	603
14	14	Standard.	474	771
12		Heavy.	623	1,012
10		Ex. heavy.	765	1,244
14		Light.	415	674
12	16	Standard.	545	886
10		Heavy.	670	1,088
8		Ex. heavy.	825	1,341
14		Light.	369	599
12	18	Standard.	484	787
10		Heavy.	596	968
8		Ex. heavy.	733	1,192
14		Light.	332	539
12	20	Standard.	436	709
10		Heavy.	536	871
8		Ex. heavy.	660	1,073
14		Light.	302	490
12	22	Standard.	396	644
10		Heavy.	487	791
8		Ex. heavy.	600	975
14		Light.	277	449
12	24	Standard.	363	590
10		Heavy.	446	726
8		Ex. heavy.	550	894

TABLE No. 2.

Approximate Weights of Spirally Welded, Lap-Welded and Cast-Iron Pipes, per lineal foot, without couplings or hubs.

Spirally Welded Steel.					Lap-Welded Iron.
Diam. of Pipe, inches.	Light, lbs.	Standard, lbs.	Heavy, lbs.	Ex. Heavy, lbs.	Standard.
6	3.65	4.66	5.87	. .	18.77
8	4.87	6.22	7.88	. .	28.35
10	7.88	9.84	12.83	. .	40.64
12	9.32	11.81	15.41	18.89	54.65
14	11.38	14.27	18.47	22.54	. .
16	17.33	21.53	26.19	31.89	. .
18	18.71	24.21	29.34	35.76	. .
20	20.68	26.37	32.25	39.63	. .
22	22.60	29.30	35.58	43.43	. .
24	24.61	31.89	38.78	47.36	. .

Cast Iron.

Diameter, inches.	$\frac{1}{2}$ in. thick.	$\frac{5}{8}$ in. thick.	$\frac{3}{4}$ in. thick.
6	31.82	40.56	49.6
8	41.64	52.68	64.27
10	51.46	65.08	78.99
12	61.26	77.36	93.7
14	71.07	89.61	108.46
16	80.87	101.82	123.14
	$\frac{5}{8}$ in. thick.	$\frac{3}{4}$ in. thick.	$\frac{7}{8}$ in. thick.
18	114.1	137.84	161.9
20	126.33	152.53	179.02
22	138.6	167.24	196.46
24	150.85	181.92	213.28

II.

NOTES ON THE APPLICATION OF ELECTRIC MOTORS TO ELEVATED RAILWAYS.

By William H. Burr, Active Member of the Club.

Read December 21st, 1889.

This paper is not designed to advocate any particular system of electric locomotion, or to defend any particular style of electric motor. It has resulted from a number of careful examinations of the question, and is intended solely to bring before the Club considerations which bear upon some feasible styles of motors and plans of locomotion in a very general way only, and with the further view, if possible, to induce a thorough discussion of the subject by the members of the Club.

The consideration of the adaptability of electric motors to the moving of trains on elevated structures leads in two directions: first, its practicability or possibility considered simply as an engineering question; and second, its economy or commercial aspect, even after its possibility, purely as a matter of engineering, is completely established.

In connection with the first of these two branches of the subject, it can be stated as a fact that electric motors of sufficient power to move four and five car elevated trains, similar to those of New York and Brooklyn, have been and are being successfully built and operated. The horse-power required to move such trains upon the elevated railways of New York City and Brooklyn, with their varying grades and curvatures, varies from 80 to 160 horse.

In the spring of 1889, the Daft Electric Light Company constructed and successfully operated upon the Ninth Avenue line of the Manhattan Elevated Railway an electric locomotive which developed for considerable periods of time, while under use, not far from 100 horse-power, and moved, on schedule time between passenger trains, four and five car trains loaded with ballast. Its experimental operation in this manner was maintained at long-continued intervals of several days to several weeks continually,

during a period of several months. It is believed it can be shown that the discontinuation of the development of this motor and of its application to the Elevated Railway service of the Manhattan Company were not due to any impossibilities or impracticabilities of the machine as a generator of sufficient power.

The Thomson-Houston Company, upon one of its lines in the vicinity of Boston, has also constructed and has in continuous operation electric motors of at least 40 horse-power, which are in incessant and uninterrupted use for the purpose of drawing trains of surface cars of the street-car type. One of the standard classes of motors which it is manufacturing is rated nominally at 80 horse-power, but is capable, like a similarly rated steam engine, of developing a much greater power.

These are isolated examples of what is already almost an extensive practice in electric power generation under circumstances of ordinary practice. It is to be remembered that the construction of large electric motors, capable of generating horse-powers of the amounts named above, dates back but a very short time, and I am authoritatively informed by officers of two of the principal electric motor companies that the development of the electrical operation of street railways has been so enormously rapid, in consequence of the high degree of success already reached, that their capacities have been seriously overtaxed to meet the requirements in this single direction, so that their attention has been concentrated on this one department of the business, to the exclusion of all others. It is also to be remembered that elevated railroads are few in number and confined altogether to three cities only, and that the demand for electric power in this special field of locomotion has not heretofore existed.

The engineering difficulties contingent upon the installation and maintenance of electric motors or locomotives on elevated railroad structures are not different in kind, nor greater in amount than those which have already been successfully encountered and overcome on street surface lines; nor can any condition be developed in the frequent running of rapid transit trains on elevated structures, equal to those which form a constant environment of the many surface lines already in most successful operation. The insulation of the conductors upon such structures will necessarily

be much more complete, and much more easily maintained than those which supply the electric power for the ordinary surface roads. Their freedom from attachment to neighboring poles by suspension wires renders them far safer to the public and insures them almost, if not quite, perfect immunity from incidental damage, and thus aids in securing for the motive power freedom from interruption from accidental or incidental causes. In fact, both tubes and overhead suspension constructions are avoided, as the conductor is simply supported on insulators attached to the timber guard rails of an ordinary railway track. The same circumstances of installation of the conductor lead to a more perfect, efficient and reliable connection between it and the motor, while the motor itself is removed far above and out of the reach of the dust and dirt and mud, or loose surface matter, which is more or less liable to interfere with those of surface cars.

When it is reflected, therefore, that no engineering problem exists in connection with the application of electric power to lines on elevated structures which has not been already successfully met in the installation of surface lines, and that the circumstances of operation and maintenance on the elevated structure are surrounded by much more favorable and advantageous conditions than on the surface, it may be safely concluded that the feasibility is an assured certainty.

There are two systems of motor arrangement which can be followed on elevated lines, either one of which, judging from what has already been accomplished, will undoubtedly operate successfully. One of these is that used upon ordinary street surface lines, and consists of placing, in each of the two trucks of an ordinary elevated car, a motor of sufficient power to propel its own car and one or two more attached to it. One such ordinary 40 horse-power motor attached to each truck of a car would be amply sufficient to propel its own car, and one in tow, over any of the lines of the Manhattan Company of New York City, or any of the lines in Brooklyn, except the stretch of three and one-half per cent. grade between Fulton Ferry and Sand Street on the King's County line, and in that case there would be only the difficulty corresponding to that in steam locomotion. Under such circumstances it would simply be necessary to use more motor cars

in ascending the grade, precisely as the locomotives are doubled in actual practice to meet the heavy grade in question.

But to return to the comparison with the Manhattan trains. A train of four cars, with every alternate one fitted with two 40 horse-power motors, would constitute an ordinary train, or six cars would be propelled by three of them fitted with motors. Such trains of four or six cars, from what is known of the power required to move those trains under steam locomotion, would pass with the same speed now made by the elevated roads over the entire system of the Manhattan Company. There would be the very material economic gain in power arising from the fact that a very large proportion of the dead weight of the locomotive, which has to be moved in addition to the paying portion of the train, would be entirely eliminated. Each 40 horse-power motor would weigh about 9,000 pounds, and would require no extra weight for fuel and water. The actual paying weight of the motor cars would be rendered available in producing tractive force, whereas in the ordinary locomotive it is the non-paying weight of the locomotive which performs that duty.

With this style of motor car, there is also a very material advantage in the maintenance of the structure, from the fact that the motor weight is distributed throughout the train, thus avoiding the heavy locomotive concentrations, and consequently avoiding also the serious strains which a structure sustains under steam locomotion.

In the other motor arrangement in which there would be a large concentration of electric power in a locomotive in which the steam would be displaced by electricity, the paying weight of the train would, of course, cease to produce any tractive force, and there would be the same heavy concentration on the structure to produce heavy local strains as in the case of steam traction. There is an economic advantage, however, in these large concentrations of power, which leads, in the case of electric motors, to a higher mechanical efficiency than in the case of the motors distributed among the trucks of the cars; the latter, also, being greater in number, offer greater opportunities for wear and cause a greater expense in the cost of repairs and maintenance.

Which of the two types would result in the greater commer-

cial economy can only be determined by a more detailed investigation than permitted by the scope of this paper. It can be stated, however, that both systems are capable of very satisfactory results.

In steam locomotives, there is what is known among engineers as a lack of balance in the reciprocating and rotating parts, caused by the large weights concentrated in the driving wheels, in order to counterbalance those of the connecting and parallel rods and their attachments. While it is possible to make this balance, according to ordinary practice, perfect in a horizontal direction, the same result cannot be accomplished at the same time in a vertical direction, and the consequence is a series of serious pulsations, which the structure has to resist when the locomotive is in motion. These strains may and do commonly amount to ten to twenty per cent. of those caused by the entire weight of the locomotive itself. In the case of the electric motors, however, whether distributed among the car trucks or concentrated in one locomotive, there need be no reciprocating parts, as the whole motion is one of simple rotation; consequently no adjustment or balance is necessary, and the motion of the trains is absolutely free from all the above-described pulsations on the structure. The stresses in its materials are reduced correspondingly, and the tendency to loosen rivets or overstrain any part correspondingly diminished.

It has also been observed in electric locomotion that when the return current passes through the surface of contact between the wheels and rails the tractive force is considerably increased. In some special cases, this increase has been as high as thirty per cent. of the tractive force due to the simple weight of the vehicle, but under circumstances of good roadbed and ordinary size of car or motor wheels, it probably does not exceed ten or twelve per cent. That much increment of tractive force, however, plays a very important part in the increase of motive power, as it enables the same motor to pull a correspondingly increased load or ascend with the same load an increased grade.

Inasmuch as the requisite power can be developed in an electric motor, trains of cars may be run at the same rates of speed as if steam locomotives were used. As a matter of experience,

it may be stated that the loss of power in transmitting electric currents through conductors required by an elevated system is ordinarily found to be about ten per cent., while the loss in the motor is about another five to eight per cent., making, under good ordinary conditions of operation, a total loss of some fifteen to eighteen per cent. of the total power applied to the system at the power station. It is to be premised, of course, that the total power applied to the whole installation will be developed at some central station or stations, in which will be placed boilers and engines of the most efficient and economical type, which engines will drive large dynamos constituting the real origin of the electric power applied to the movement of trains over the various lines.

The detailed consideration of the second or economic part of the subject requires a more extended investigation than is offered by the limited time and circumstances under which this paper has been prepared. In consequence of the fact that the entire service of any one elevated line has not been operated by electric power, the requisite data are much more difficult of access. Experience in the operation of electric motors has shown that the actual cost in money of one horse-power per year, including all the incidental expenses of actual operation and repairs and maintenance of machinery, is about one-third as much as for steam locomotives. This result is due to the fact that the locomotive is by far the most wasteful consumer of coal of all well-constructed machines, as well as to the further fact that the repairs and cost of maintenance are also much greater in locomotives than in electric motors and the well-established stationary steam engines and boilers of large electric power plants.

Estimates for elevated railway lines, five to seven miles in length, indicate that the entire plant, including central power station, dynamos, conductors, motors and cars, complete and ready for the running of trains, will, at present prices, cost about seventy-five per cent. more than the corresponding equipment under the ordinary steam locomotion, including coal and water stations, machine shops, locomotives, cars, etc. But the very material saving in expenses of operation and maintenance can be shown to capitalize a sum equal to this difference in first cost, and leave a

margin in favor of the electric system. It is believed also that an elevated railroad operated by electric motors would be much more attractive to those accommodated by rapid transit than if the ordinary steam locomotives were used.

All cars would be fitted with electric lights, operated by the electric power available in every train. These features of elevated lines would attract an increased traffic, which also should be credited to the electric motive power. Every advantage which the electric system would possess at the outset would, with the rapid developments now being made in that branch of engineering, be enhanced very rapidly in the future.

Although the first cost of electric equipment will exceed that of steam equipment, it may be confidently expected that the total economy is largely in favor of the former. The electro-motive force of the current employed in elevated electric locomotion could easily be kept at 500 to 600 volts.

III.

ECONOMICAL FORM AND CONSTRUCTION OF ARCHES IN RAILROAD EMBANKMENTS.

By Charles S. Churchill, Active Member of the Club.

Read January 18th, 1890.

The following statements are based—

First.—Upon personal observation of a large number of arches of long standing, built by various engineers.

Second.—Upon the behavior of a number of arches designed and built by the writer.

Third.—Upon the results obtained from the study of the best and most economical form of arches under banks of loose material liable to settlement, the proper dimensions having been determined in each case by considering the actual strains on the arch and analyzing the same by the graphical method.

These statements are submitted without argument to any extent,

as representing the writer's opinions and conclusions on this matter, and in order that this important subject may be brought up for a general discussion.

First.—Arches under railroad banks should be proportioned to bear the moving load in addition to the full weight of the bank directly over them. It is not safe to assume that the pressure over an arch is the weight of a wedge-shaped body having a width of base equal to the span of the arch; but the pressure should be taken as the weight of a prism of bank, with a base equal to the span of the arch and a height equal to the full height of the bank over the arch.

Second.—Large factors of safety may be added to buried arches by simply placing the bank material over the structures in horizontal layers and packing the same. If this be done, the layers have a tendency to form a support to the upper part of the embankment, the same as layers of brickwork directly over a break in a wall. It has often been noted that the upper part of such a break in brickwork always takes the form of a wedge, the base of which is the width of the opening. The weight of this wedge of material can, therefore, be said to represent the pressure which a supporting beam would be required to sustain at the opening. Therefore, the more nearly an embankment is made to resemble a piece of brickwork in layer formation, the less the pressure over a buried arch.

Third.—Solid foundations and a careful proportioning and construction of arch abutments are of the first importance, as their failure or settlement brings disaster at once to the arch.

Fourth.—The perfect arch is one whose parts are bound together so as to form as nearly as possible a homogeneous mass. Such a structure, properly proportioned and built of good material, will retain a perfect form for ages.

Fifth.—An arch may be said to fail when a break occurs in it, or when any of its stones settle out of line; though such a faulty structure may possibly stand in this condition for years after such failure occurs.

Sixth.—From the above it appears that it is a mistake to introduce materials of varying degrees of hardness into arch construction. The character of the stone to be used and the fine-

ness of the dressing of that stone should determine, not only the width of the joints in the sheeting stones, but also the strength of the cement to be used.

If brick be adopted for the arch sheeting, then a cement of the same strength as the brick is the proper kind to use in binding them together.

If the arch is of rubble masonry, then the strength of the cement used may be considered as determining the strength per square foot of the arch sheeting.

If a first-class cut stone arch is to be built, the stones should be cut carefully for small joints of about one-eighth of an inch, and these joints should be filled with the best Portland cement mortar. It is quite useless to waste time and money in cutting arch stones carefully, and then lay them with joints of over one-fourth of an inch, as in this case the strength of the cement alone determines the strength per square foot of the arch sheeting, and the strength of the cement is nearly always less than that of the stone.

Let any person, desirous of examining into this point, look carefully over railroad arches which have been standing for from ten to forty years and note the number of failures—the large number with nicely cut sheeting stones lying badly out of line and in all sorts of positions, the mortar having first dropped from between them.

Let the same person examine other arches, possibly of rubble masonry laid in good cement mortar, which have stood in perfect line and form for as many years as other cut stone arches have existed, and the truth of this last general statement will undoubtedly be apparent without further demonstration.

Seventh.—The importance of covering the whole top and crown of all arches, and especially brick and rubble arches, with a coating of strong cement mortar, so as to either turn the water off entirely or carry it to proper channels provided for it, thus preventing leakage through the arch sheeting, is often overlooked. This simple precaution adds not only to the durability of the structure, but also to the appearance of the interior of the arch.

Eighth.—The form of a buried arch which allows of the least masonry, and, therefore, the most economical form, is one having

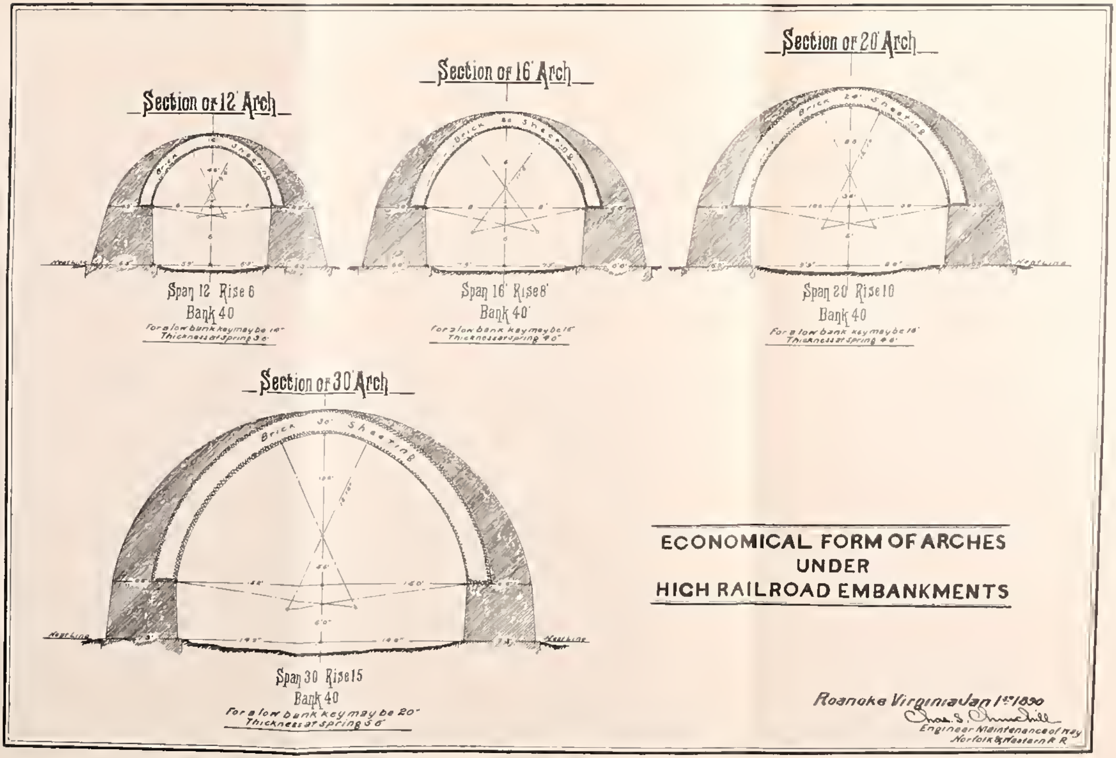
a soffit which may be best described as a parabolic curve, though it is made up of circular arcs and the real shape is between the ellipse and the parabola.

The accompanying plan shows the most economical cross-sections of buried arches of twelve feet, sixteen feet, twenty feet, and thirty feet spans, in embankments of sixty feet in the case of the thirty feet span, and forty feet in the other spans, the arch sheeting being formed of first-class brickwork. All the dimensions are given, together with the corresponding dimensions of the same arches in low embankments. These dimensions have been determined by calculating all the strains and analyzing the same by the graphical method in each case.

The dotted line shown on the cross-section of the twenty-foot arch is the soffit line of a full center arch with radius of ten feet. When it is noted that the parabolic soffit line shown on this cross-section is parallel to the central line of pressure in the arch, it will at once be understood that the parabolic arch is much safer than a full center arch; and it will be further understood that a full center arch, in order to be equally safe with the one shown, must have a much thicker sheeting and be heavier at the springing line.

Ninth.—As the best arch is the one whose parts are so united as to make nearly a homogeneous mass of the whole structure, it becomes apparent at once that, as regards strength and durability, it is immaterial whether the ends of a buried arch are cut square or skew with the barrel. The so-called "false skew arch" is as substantial and safe a structure as an arch with square ends, or as a regular skew arch whose sheeting stones have each been carefully cut at great expense to the warped surfaces required in its formation. The angle of skew of a false skew arch is limited by the safe angle for cutting the outer face of a ring stone. In the estimation of the writer, the ends of a false skew arch may be cut off at an angle with the barrel as small as sixty degrees, and all portions of the structure will still be as safe as an arch with square ends. Arches of twenty-five feet span, however, have been built with ends cut at as small an angle as fifty degrees without damage to the sharp corners of the ring stone.

It is, of course, hardly necessary to add that all the false skew


Section of 12' Arch
Span 12 Rise 6
Bank 40
For a low bank key may be 14"
Thickness at spring 3 6"
Section of 16' Arch
Span 16' Rise 8'
Bank 40'
For a low bank key may be 16"
Thickness at spring 4 0"
Section of 20' Arch
Span 20 Rise 10
Bank 40
For a low bank key may be 16"
Thickness at spring 4 6"
Section of 30' Arch
Brick Sheeting
Span 30 Rise 15
Bank 40
For a low bank key may be 20"
Thickness at spring 5 6"
ECONOMICAL FORM OF ARCHES
UNDER
HIGH RAILROAD EMBANKMENTS
Roanoke Virginia Jan 1st 1890
Chas. S. Churchill
Engineer Maintenance of Way
Norfolk & Western R. R.

arches that have been either built by the writer or brought to his attention by other engineers, or through the engineering journals (of which last there are large numbers), are as sound as the square arches on the same railroads.

Tenth.—In conclusion, it is a well-known fact that there is more "rule of thumb" used about the proportioning of the ordinary sizes of railroad arches than in almost any other structure. While every detail of a bridge, be it of wood or iron, is very carefully designed, the stone arch is simply built so that it has positively abundant strength, existing structures generally being taken as guides, and but little attempt being made to look into the economical arrangement of its parts. This method, or rather lack of method, makes the arch appear in comparison to the iron girder as a very expensive structure; whereas, if the same proportion of excess material was to be placed in the girder, the latter would almost invariably be found to be the more expensive structure. It is a conceded fact that a well-built arch is a more desirable railroad structure than a plate girder. In fact, the iron girder provided with a buckle-plate floor and covered with ballast, is the only structure that has very many of the points of excellence possessed by the arch. The stone arch, except in special cases, surpasses even this structure in desirability, probably in durability, and certainly in cheapness. It would seem, therefore, very wise for us at this time to look back a little over some of the work of the engineers who built the older railroads. We may acknowledge their wisdom in building stone arches for permanent structures. We may go further and follow their footsteps in adopting, even more generally than at present, this same structure for permanent work, being assured that when the arch is carefully designed we are not building a more costly structure than a first-class one in which iron is employed.

IV.

RE-ENFORCEMENT OF FOUNDATIONS AND LEVELING OF TRACK OF IRON DRAWBRIDGE.

By Howard Constable, Active Member of the Club.

Read March 1st, 1890.

The following account of the re-enforcement of the iron piles forming a draw-pier may be of interest to engineers as a quick piece of work, and instructive to architects as a suggestion for re-enforcing or underpinning the walls of buildings. It will be seen that for this latter case the method has many applications, and that with some calculation and careful regard to the direct and cross strains and to the construction of details of the connections, it is very practical and economical for many cases where stories are to be added to a building, where local settlements need to be checked, where alterations have concentrated extra weight upon certain piers, and where there is no authentic record of the old footings and foundation soil. Many an architect will recall cases such as this last, where any method would have been welcome that avoided the long, expensive and cumbersome system of shoring and underpinning.

Two years ago we were called in to discover and correct the sticking and warping of the ends of the iron draw span of a double-track highway bridge.

The draw was a through span, and the approaches were deck spans, all riveted construction. The draw span rested upon a group of fifteen cast-iron piles, arranged in a circle as shown in the plan, Fig. 1, and driven in a hard sand bottom by means of a hammer, aided by a hydraulic jet, most of the piles being fitted with a large cast-iron disk or shoe (not shown in the figures) at foot.

The bridge had been in use some six or seven years, when there commenced to be very considerable difficulty in turning the draw. The ends of the floor on the draw would not meet those of the fixed spans, so that the floors had to be built up in order to enable vehicles to pass from one to the other.

When we were first called in to investigate, we found the warp at the ends was about two inches, and that the amount had been sometimes more and sometimes less than this; also, that during the two preceding years attempts had been made to correct the trouble by wedging up the drum, the rollers, the turn-table track, etc.

A level was strapped to the middle pile of the draw-pier, and the level of the turn-table track taken. The profile of this track, Fig. 2, shows the irregularities discovered. A good enough profile for a cross-cut saw, but scarcely for a turn-table track. A careful investigation of the river bed and of the river itself, both above and below the bridge, showed that the contraction of the cross-section by the extension of bulkheads into the stream, by clumps of fender piles above and below each iron pier, and by the pivot-pier itself, had caused a scouring of the bed, which consisted of sand, underlaid at varying depths by a bed of ferruginous gravel. This scouring had deprived some of the piles of a portion of their support, and a continuous and irregular settlement naturally followed, with the results already described. The settlements had also been aggravated, no doubt, by the vibration caused in driving some of the piles without shoes. Of course the difficulty could only be temporarily cured by wedging up the drum.

The bridge was subject to a great amount of travel, and also to great demands upon the draw from passing vessels. The roadway overhung the circle of piles in the draw-pier, and the latter was surrounded, and rendered somewhat inaccessible, by a heavy fender and bracing.

It was decided that it was impracticable to stop traffic, or the opening of the draw, for more than a few minutes at a time during the day, or for more than an hour during the night; also, that any new work must be of iron. It was, therefore, impossible, without great expense, to replace the old piles by new ones with greater bearing surface or deeper penetration.

The method adopted was to drive a new wrought-iron pile N (Figs. 3, 4, 5 and 6) outside of and adjoining each old pile P, which latter was then fitted with a cast-iron bracket B, by means of which, and of two stud-bolts or set-screws, S S, any desired

portion of its weight and load could be transferred to the top of the new pile. The drum and track were then to be leveled up.

The new or re-enforcing piles were of double extra heavy pipe-line pipe, thoroughly tarred and driven to place, and the brackets were made of extra tough cast iron by Messrs. J. B. & J. M. Cornell, who gave special attention to the mixture, to the perfection of the castings and to the fitting.

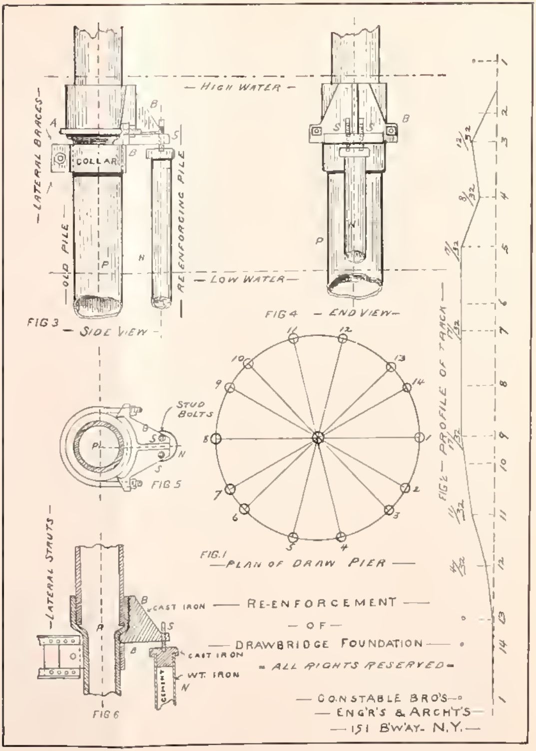
The old piles were made each in two sections, with a bell-and-spigot joint, as shown in Fig. 6, and advantage was taken of this by making the brackets with a lip fitting under the shoulder of the hub of the old pipe. This avoided the necessity of boring and bolting into the old piles. The brackets were accurately fitted to the old piles and secured to them by heavy wrought-iron straps.

The old piles had been driven home, so that their shoulders (and consequently the new brackets also) were, of course, at different levels, and we could not expect to be able to drive the new piles to the exact distances required. They were, therefore, made of lengths to suit the soundings, and driven as far as they would go. Then the distances were measured from the top of each new pile to the bottom of the corresponding bracket, and pieces of pipe cut to these lengths at the factory, and secured on top of the new piles by means of long steel screw-couplings, such as are used on pipe-lines.

The new pile was then pumped out and filled with concrete. The cast-iron cap, provided with sockets for receiving the feet of the stud-bolts, was then put in place, the bracket swung around over it, and the straps tightened. The stud-bolts were next set to place with six-foot wrenches, and it was calculated that about thirty per cent. of the weight and load of the old piles was transferred to the new ones. All the iron work was treated hot to a bath of tar in the shop, and tarred again when in place.

Much difficulty was experienced in getting the brackets into place, owing to the tide and to the number of struts and tie-rods forming the lateral bracing of the pier.

But perhaps the most troublesome part of the undertaking was the driving of the new piles; the fender-piles and cross-timbering of the pivot-pier being much in the way. The contractor


HIGH WATER
LOW WATER
LATERAL BRACES
OLD PILE
RE-ENFORCING PILE
COLLAR
FIG 3 — SIDE VIEW
FIG 4 — END VIEW
STUD BOLTS
FIG 5
FIG.1 PLAN OF DRAW PIER
FIG 2 PROFILE OF TRACK
LATERAL STRUTS
CAST IRON
CAST IRON
WT. IRON
CEMENT
FIG 6
RE-ENFORCEMENT
OF
DRAWBRIDGE FOUNDATION
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ENG'R'S & ARCHT'S
151 B'WAY. N.Y.

would not undertake to do this part of the job, except by day's work, and we found that he expected there would be about twelve days of it. So the extra contract was made for day's work, and the contractor ordered to be ready with his driver and men at 7 o'clock in the evening prepared for a little night-work. A pair of special guides had been provided, and attached during the afternoon to the railing of the draw-span and braced to the trusses. The 2,000-pound hammer was transferred to these guides, the driver located at the end of the fender, out of the way of the channel, and the hammer-rope led through snatch-blocks to the engine-drum. Men were stationed at the ends of the bridge, to give notice of any approaching traffic, and the draw was swung around over each pile, or closed on signal. By 7.35 the next morning the fourteen piles were all driven, and the contractor was paid by the day—or rather night.

When the turn-table track was leveled, the bridge came back to its proper bearings, and it has worked well and remained in good condition ever since.

Some little trouble had been experienced in opening the draw during the middle of the day in hot weather. To remedy this, the upper chord was painted white, which seemed to be quite effective in reducing the amount of its expansion and removing the trouble referred to.

V.

ON THE PURIFYING EFFECT OF SAND FILTRATION.

By B. H. Coffey, Active Member of the Club.

Read March 1st, 1890.

I beg the Club's pardon for imposing anything connected with the hackneyed subject of the water supply. Very little, however, has been said regarding filtration, and as I am somewhat familiar with the subject, I thought a few words as to just what sand filtration can and cannot do might not come amiss.

The popular idea of sand filtration is that it is a mere straining action; a partial or entire removal of suspended matter, the substances in solution remaining untouched. This, like many popular fancies, is, in the main, though not strictly, true.

Humber states that vinegar, on being passed through sand, loses most of its acid, the action gradually decreasing until the sand becomes charged, when the liquid passes unaffected. Potato brandy, diluted with water, on being passed through sand, yields first water, then water and alcohol deprived of its fusil oil, and lastly, the original mixture. He also says that salt may be partly removed. This last statement is confirmed by the fact that fresh water may be obtained on almost any sea beach from a driven pump, the water, of course, filtering through the sand from the ocean. These facts are interesting, and, as far as I am aware, unexplained by theory; they would seem to show that soluble matters are removed, to a certain extent, by percolation through sand.

It is, however, with suspended matters that we have principally to deal; and here the cause and effect are very obvious.

In a polluted stream, like the Schuylkill, for instance, the dissolved matters, as far as I can see, are small in quantity and, as far as health is concerned, innocuous. They consist principally of chlorine, sulphuretted hydrogen, nitroginized substances, lime salts, and, maybe, a trace of sulphuric acid and other chemicals from the numerous mills and factories that adorn its banks. These impurities, if present in large quantities, might be harmful; as it is, I know of no disease traceable to any of them.

It is the suspended matters that cause the death and destruction we hear so much of in the daily press, for among them are the germs, which, modern science says, are the seeds of disease.

It will be fair to assume, then, that in the measure they are removed, will be found the efficiency of sand filtration from a hygienic point of view. In the discussion of this subject, I will make three divisions: first, the theory; second, the biological and chemical results of experiment; third, the sanitary results in practice.

Theory.—The mutual attraction of floating particles is a familiar phenomenon. Two pieces of wood thrown into a tumbler of water will be drawn together. Clay, in a finely divided state in

water, will deposit on the sides as well as the bottom of the vessel. In fact, I believe that the principal cause of the final deposition of the finer particles is due to this action. They are drawn together, and when the mass becomes sufficiently heavy it sinks. So powerful does the bond become, that I have been unable to reproduce the original finely divided state after subsidence, even with violent agitation. I have never heard of these facts being satisfactorily explained. I will hazard the theory that it may be due to gravity. If two bodies were placed in a perfectly frictionless medium, and all external forces eliminated, they would certainly follow the well-known law. And does it not seem that a mobile fluid like water would fulfill these conditions very perfectly? And now to return to the germs. Exactly what they are, animal or vegetable, the bacteriologists seem still in the dark. From our point of view, however, this is a matter of indifference. That they are finely divided matter no one will dispute, and being so they must necessarily follow the law we have indicated. And now, how to get rid of them.

From the above we may deduce two distinct methods, which often may be advantageously combined:

1st. To expose a relatively large depositing surface, to a relatively small volume of liquid. When you consider that a cubic inch of sand particles, .01 inch in diameter, exposes a surface of 314 square inches to a cubic inch of water, you will see what a perfect medium it is for the purpose.

2d. To introduce finely divided matter into the liquid, which will attract the germs, and, in settling, carry them down. This is most perfectly accomplished by adding some precipitating agent, like alum, for instance. When this salt is added to water, carbonate of alumina is formed. It separates as a sticky gelatinous precipitate. The particles are at first so small as to be invisible; they are quickly drawn together, however, according to our law, and, owing to their sticky property, adhere closely. They soon become heavy enough to settle, and, in doing so, carry down all suspended matter, germs included. The combination of these two methods, as it is ordinarily practiced, should certainly, on theoretical grounds, produce very good results.

I now come to the results of experiment and will try to bore you with four-place decimals as little as possible.

The water of a polluted stream, containing many thousand germs per cubic centimeter, is found to be very much improved on entering a lake where subsidence can take place.

Dr. Percy Frankland found that a large reduction in the number of germs could be obtained by simply agitating finely divided matter with the water and then allowing it to settle. He found the action of a precipitant even more efficient. In one instance a company using Clark's lime process effected a reduction of 99 per cent.

These experiments were repeated and the results fully confirmed by Prof. Kruger of Jena.

The results of filtration are just as satisfactory. Dr. Frankland found that the average reduction in the number of germs, effected by the London filter beds, over the original Thames water, for four months in 1885, was 98 per cent.

In the report of the State Board of Health of Massachusetts, 1888, on water supply, I find that sand filtration caused an average reduction in the albuminoid ammonia (which stands for the germs from a chemical standpoint) of about 77 per cent.

Dr. Courier, of New York, experimenting with a sand filter, employing a precipitating agent, obtained sterile water.

I could cite many other experiments, but it seems that the point that filtration will remove the germs is thoroughly established by the above.

In dealing with the actual results of purer water supply on health, I am largely indebted to Dr. E. O. Shakespeare. He states that the average deaths from cholera in Calcutta, from 1841 to 1870, were 4,000 yearly, while in 1870, after an improved supply was introduced, the number sank to 250. In the cholera epidemic of 1866, at London, the disease was confined to the locality supplied with unfiltered water. On changing the supply, the epidemic ceased.

In London, the typhoid death rate for 1849 was 61.8 per 10,000; in 1866, after filtration was generally introduced, it sank to 14.4 per 10,000.

These figures are very significant and fully bear out the theoretical and experimental propositions. The deaths from typhoid in Philadelphia, Boston and New York for 1880, were respectively

1 in 1,560, 1 in 1,982 and 1 in 3,649, or a difference of 134 per cent. in favor of New York.

In 1880, London, with probably the most complete filtration system in the world, stood bottom on the list, with one typhoid death in 10,409. Philadelphia stood fourth from the top.

When you consider the polluted condition of the unfiltered Thames water, from which London's chief supply is drawn, this certainly speaks very eloquently for filtration. In the old and thickly populated countries of Europe, the conditions toward which we are rapidly approaching are already fully realized. It has been found impossible to free the water sheds of contaminating influences. The polluted water was not fit for drinking purposes, and yet these streams were the only available source of supply.

The problem has been met and solved by filtration. The principle is applied at both ends of the difficulty; the sewage is first subjected to a filtration process before entering the stream, and the water for personal use subjected to filtration before being supplied. I may say this method has become universal all over Europe. And when you consider the difference in cost of applying this method, over the only other I know of, practically banishing population from the water sheds, I think it would show a very large financial economy.

VI.

THE MOUNTAIN RAILROADS OF READING, PA.

By William H. Dechant, Active Member of the Club.

Read May 3d, 1890.

The city of Reading has a population of about 65,000 inhabitants, and is situated in Berks County, on the Schuylkill River. The average altitude of its streets is about 270 feet above midtide. It has a number of natural advantages, among which are these: The rich farming districts surrounding it; its water sup-

ply is taken mostly from mountain streams and springs by gravity; building materials, excepting timber, are abundant within the city limits; commercially, it is important in manufactures, and has excellent railway facilities furnished by the Philadelphia and Reading and Pennsylvania Railroads. The natural advantage to which this paper is especially intended to refer is its picturesque mountain surroundings.

The long crest of Mount Penn flanks the city on the east, running almost directly north and south. The Neversink Mountain bounds the city on the southeast; its crest line is divided into a number of ridges and summits, having a general east and west direction.

The highest part of Mount Penn has an altitude of about 1,120 feet above mid-tide, and the highest part of Neversink Mountain an altitude of about 875 feet. Taking 270 feet as the altitude of the average streets, the crest of Mount Penn would be 850 feet above the city, and the highest part of Neversink Mountain 605 feet. The city limits extend up the foot slopes of these mountains, and the tide of advancement has sent its streets up their sides, until they reach a grade of nearly 20 per cent. in some places.

The mountains are covered by a growth of chestnut, oak, laurel and patches of pine and cedar, with points where no growth exists on account of barren rocks. These mountains are the attractive feature in the landscape of this section; heretofore their summits, commanding magnificent views of the surrounding country for twenty, thirty and more miles in extent, have been accessible only to persons able to endure tiresome climbing, with the exception of a portion of Neversink Mountain which has had a drive constructed by the Klapperthal Company, owning a large part of the mountain, to the highest point, and to an observatory erected at that point, and also by an inclined plane running to a summer resort called the Highland House, located at a point on the mountain in line with Thirteenth Street, and being at an altitude of about 500 feet above the average city streets. The use of the drive was, however, beyond the masses of the people, on account of the expensive feature of horses and carriages, and the inclined plane is not constructed or equipped to be capable of handling crowds, or to attract people in any degree timid.

The matter of a gravity railroad on Mount Penn was thought of five years ago and brought to the attention of a number of the business men of the city, until, one year ago, the enterprise assumed definite shape and work was begun. The preliminary surveys on Mount Penn were not completed before the company of gentlemen owning a large part of the Neversink Mountain incorporated the Neversink Mountain Railroad and began work on that mountain also, so that within the short space of a year the city of Reading will have acquired, in the shape of two railroads, each more than seven miles long, facilities that will throw open the attractions of its mountain surroundings.

The original plan for the Mount Penn Gravity Railroad was to ascend the mountain to its highest point by an inclined plane, and from this summit to descend by gravity along the route, to the foot of the plane near the head of Penn Street; but owing to obstructions placed in the way by property owners near the city, the terminus of the road has been placed in the Mineral Springs Park, near Nineteenth and Perkiomen Avenue, at the terminus of the Perkiomen Avenue street car line, and near the terminus of the city passenger railway. At this starting point, where it has an elevation of about 200 feet above the average city streets, it ascends the mountain 658 feet higher by a heavy grade road, $2\frac{42}{100}$ miles long; the uniform average grade would be $5\frac{15}{100}$ per cent., but it was found necessary to increase this in a number of places, and in one place, for a distance of 700 feet, a maximum of $6\frac{5}{100}$ per cent. is used. The alignment in the ascent is also of necessity severe, having two short curves, about 100 feet long, of $146\frac{19}{100}$ feet radius, or 40 degrees, and these on 6 per cent. grades. There is a 49-degree curve (radius $120\frac{57}{100}$ feet) on the ascent where the road passes to the front of the crest near the summit; but the grade at this point is only $1\frac{6}{10}$ per cent. The most severe curve to operate on the ascent is a 20-degree curve (radius $287\frac{94}{100}$ feet) on a 6 per cent. grade and 750 feet long. The summit of the road is at the highest point on the crest of Mount Penn, called the "Black Spot." From this point the gravity part of the road begins, descending by 1 to $1\frac{6}{10}$ per cent. grades, except around sharp curves, where the grades are increased to compensate for the curvature.

There are two points in the descent where curves of 75 feet radius are used to make turns on the side of the mountain, and two points where curves of 100 feet radius are put in to turn on the crest of ridges. The length of the descent is $5\frac{6}{100}$ miles, making a total of $7\frac{48}{100}$ miles in length for the whole road. The route of the road in the ascent is through the Mineral Spring ravine and up back of the mountain, until, within about 1,000 feet from the summit, it passes around the crest, to the front of the mountain, where the Lebanon Valley and the city of Reading burst into view. From this point to the summit, and for 4,500 feet north of the summit, the road runs along the front of the crest line, then turns to the east side of the crest and traverses the undulating table-land back of the mountain, circling around prominent points commanding extended views of the valleys toward the east, and passing through more cultivated districts, to the starting point.

The road is in operation. The motive power at present is a Baldwin locomotive weighing about 22 tons. This locomotive is capable of drawing two cars, carrying together 150 people from the starting point to the summit at the rate of twelve miles per hour. From the summit the cars run on by gravity, and the engine returns to the starting point The speed of the cars on the gravity portion is kept to twelve miles per hour, so that the round trip occupies about 40 minutes. The company has contracted for two more locomotives of the Shay pattern, which are now on the way. These locomotives weigh 28 tons, and are geared engines, especially adapted for running sharp curves and steep grades. They are expected to draw three loaded cars to the summit. With this capacity, and making the trips 15 minutes apart, they expect to be able to handle 1,000 passengers per hour. The traffic on the Mount Penn Gravity has been good. On several occasions, with their present facilities, they were unable to accommodate all the people. The intention of the persons in charge and interested in the road is to establish hotels and pavilions on its route to make attractive summer resorts for excursionists and others.

The Neversink Mountain Railroad has its terminus at Ninth and Penn Streets, near the heart of the city. From this point, it

runs southward out Ninth Street and the White House road, about one mile within the city limits. At Ninth and Penn Streets it has an altitude of 282 feet above mid-tide and only 12 feet above the average city streets. About 2,000 feet from the starting point it reaches its lowest altitude on the city side, 230 feet above mid-tide or forty feet below the average streets, and from this point it ascends by grades between 1 and $6\frac{4}{10}$ per cent. to the White House, $1\frac{1}{8}$ miles from the starting point—the $6\frac{4}{10}$ per cent. grade being 900 feet long. At the White House the road which has been running in a southerly direction terminates in a switch, and from there runs in a northeastwardly direction to keep on the northern side of the mountain in view of the city. The altitude at the White House is 406 feet above mid-tide, or 136 feet above the average city streets. From this point up the mountain a uniform grade of $3\frac{94}{100}$ per cent. is maintained for a distance of $1\frac{8}{10}$ miles, to a point where the road turns through a gap around a point of the mountain; at this point the altitude is 770 feet above mid-tide and 500 feet above the average city streets. From this point the road descends by 1 and $1\frac{6}{10}$ per cent. grades for 2,000 feet, crossing over a depression in the mountain to reach another summit, which it ascends for 1,500 feet by a 4 per cent. grade, reaching the *summit of the road* at an altitude of 806 feet above mid-tide, 536 feet above the average city streets, and 576 feet above the lowest part of Ninth Street. After passing the summit the road descends by from $2\frac{4}{10}$ to $3\frac{64}{100}$ per cent. grades to its southern terminus, where it makes direct connection with the Philadelphia and Reading Railroad.

The alignment from the city to the White House has a number of short curves of 75 feet radius through turnouts and around a street corner. Beyond that, the most severe curves are 40 degrees ($146\frac{19}{100}$ feet radius), and four in number (with others less severe), along the precipitous side of the mountain, and on a $3\frac{64}{100}$ per cent. grade. These curves are short, however, the longest one being 195 feet.

The length of the road from Penn Street to the summit is $3\frac{62}{100}$ miles, and from the summit to the southern terminus is $3\frac{33}{100}$ miles, making together nearly seven miles.

The route of the road has been carefully planned to take ad-

vantage of the prominent points of outlook, and also with a view of giving access to the greatest amount of property on the mountain, much of which is very well adapted by the character of its surface for the location of private residences, hotels and summer resorts. From the White House the line passes along the north side of the mountain in an easterly direction, in full view of the city, until it passes around and back of Observatory Point, through what is called Goods Gap. From this point it undulates over the top of the mountain, passing in front of the Highland House and around the western end of the mountain, running thence southeastwardly to its southern terminus, and passing over the famous Klapperthal ravine by a trestle 35 feet high.

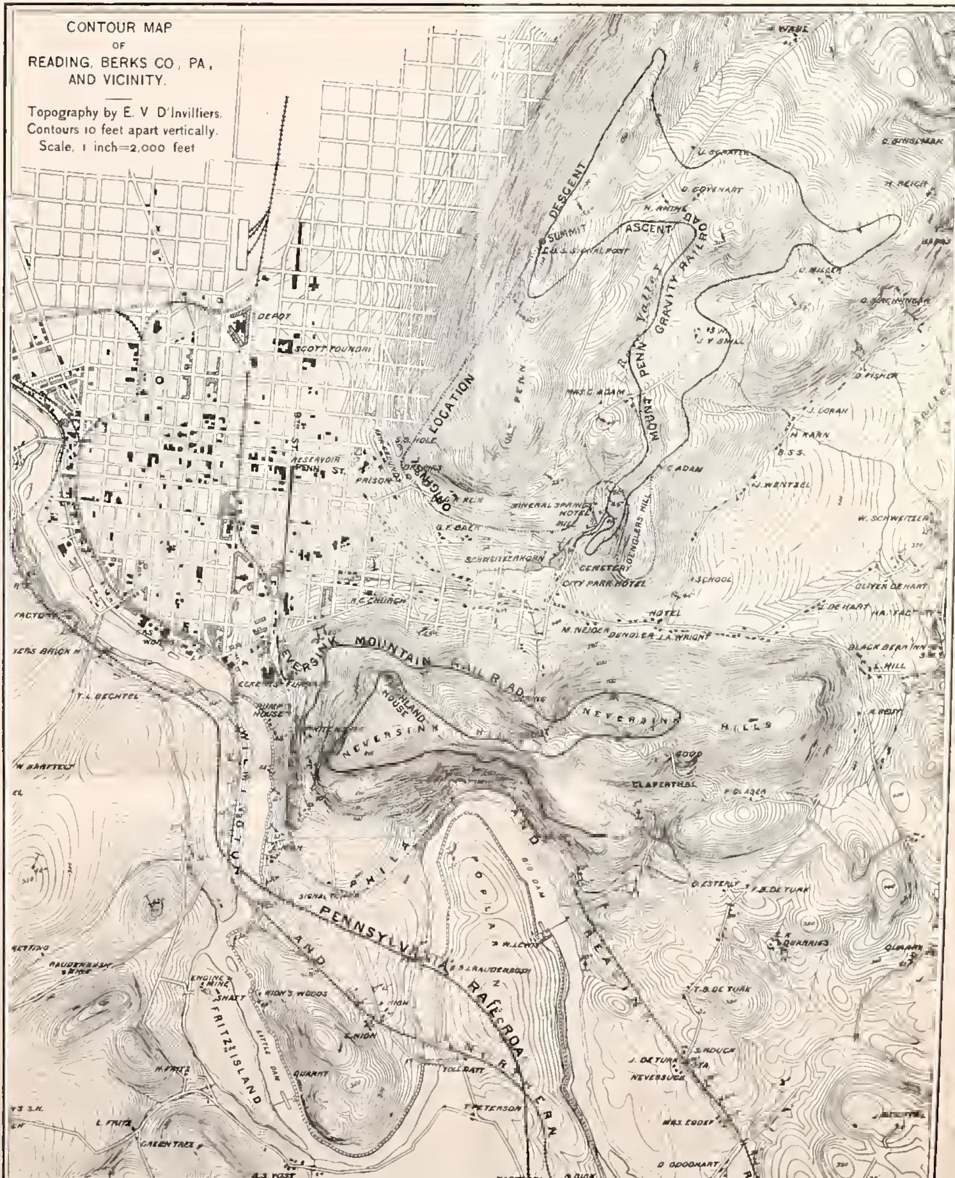
The beauty of the scenery along the western and southern sides of the mountain is very much enhanced by the windings of the Schuylkill River and its valleys, of which there is an almost uninterrupted bird's-eye view. Its direct connection with the Philadelphia and Reading Railroad will make it possible to receive and handle large excursion parties promptly.

It is expected that the construction of the Neversink Mountain Railroad will be completed in June next and that the road will be in operation in that month.

The motive power is to be electricity, generated by a water-power plant located at the big dam below Reading, close to the southern terminus of the road, to which I desire to call your attention later on, after it is in successful operation.

The electrical equipment is being furnished by the Sprague Company; the two motors on each car are to have a combined capacity of 30 horse-power. The overhead system is to be used. This road does not make a circuit as does the Mount Penn Gravity road, but the cars run in both directions over the same route, passing each other at passing sidings located at proper intervals.

Both roads are constructed to the standard gauge of 4 feet $8\frac{1}{2}$ inches, with steel rails weighing fifty to fifty-six pounds per yard, the Neversink Mountain using tram rails within the city limits. Both roads use double-truck cars and will be equipped throughout in a thoroughly substantial manner.



DECHANT. MOUNTAIN RAILROADS OF READING, PA.

VII.

THE INTER-OCEANIC CANAL PROSPECT IN 1890.

By J. Foster Crowell, Active Member of the Club.

Read May 3d, 1890.

It was the writer's privilege, rather more than four years ago, to present to the Engineers' Club of Philadelphia a paper upon the problem of inter-oceanic communication,* written while the work at Panama was in full blast, and when its projectors were promising to the world that it would be completed and opened to commerce in 1889. On the other hand, the Nicaragua scheme was still in embryo, although the surveys made in previous years had crystallized into definite plans.†

The object of that paper was to so present the facts concerning both that the entire and hopeless impracticability of the one and the abundant promise of the other should be demonstrated. How far the writer succeeded he does not know, but the irresistible logic of circumstances has since attested the correctness of the views concerning Panama, and the reasons for the faith that was in him then of the ultimate success at Nicaragua have but gathered force and cogency through later developments.

In November last, at the close of the very year that had been designated for the fulfillment of the Panama project, he passed over the mighty wreck and saw the grave of two thousand million francs ($400,000,000) of French money, that had been obtained on false pretenses and expended in lavish disregard of economic method.

Just previous to that, he had been in Nicaragua going over the final location of the canal line, examining the sites of the dams, locks, flowage-embankments, breakwaters and other structures, and studying the conformation and characteristics of the great cut through the Deseado Divide which is to be the *pièce de résistance* of the entire work. Both visits were made in a private capacity and for personal ends.

* "The Present Situation of the Inter-oceanic Canal Question." Read February 6th, 1886.—Proceedings of Engineers' Club, Vol. V., No. 3, p. 238.

† The three colored lithographs accompanying this paper have been kindly furnished by the Nicaragua Canal Construction Company, A. G. Menocal (Active Member of the Club), President.

With this introduction as excuse for again appearing before the Club with this subject, he ventures to offer as a memorandum a brief synopsis indicating the actual prospects at Panama and Nicaragua.

It is not enough to say that the Canal Panama is dead. Some people, many perhaps, believe in the possibility of its resuscitation. No one, probably, so believes who has traversed the Isthmus during the past year and is at the same time competent to form an opinion, but nevertheless the impression is more or less general that the canal *might have been built* with the money that was spent. Germany may think it failed because France attempted it—Americans because they themselves did not. It is not uncommon to meet men to-day who say they think it may yet be built under better auspices. A few say they know it was born dead; that it never had a chance of life; that it *cannot be built* by any nation or any men except for a sum of money utterly unattainable. Such persons, it may be remarked parenthetically, are characterized in the language of the day as "Nicaraguan Cranks;" it is a fact that they generally believe in Nicaragua, but these two ideas are by no means interdependent; indeed the public usually has doubt of Nicaragua, because of, and only on account of, the failure at Panama.

The following extract from the writer's journal may be relied upon as an essentially correct statement of the condition of the abandoned works at the time of his visit. If the criticism be made that it is not a scientific description, the answer is that science had already done with Panama.

"Notwithstanding all I had read, heard and written about the canal, and despite previous knowledge of the region, its topography and its difficulties, I was utterly unprepared for the scene of ruin and misdirected energy that burst upon my gaze at Monkey Hill and continued in one vast panorama of wreck, until the untouched ground near the city of Panama was reached.

The general effect was appalling, and further insight but increases the impression; and yet, appearances are said to be vastly better than when the work stopped; the immense numbers of locomotives, cars, mud-diggers, steam shovels, dredging machines, lighters and other plant have recently been collected and assorted, and ranged in line, side by side; many of them housed in or

shedded over, and all of them nicely painted, in anticipation of the new commission who are expected here next month (December, 1889), and who are also expected to recommend the resumption of the work.

Great quantities of heavy steel rail, used in the contractors' tracks have been reclaimed and piled, although much is still in dead track on the work. A large number of men (comparatively speaking) are busily engaged in unearthing, recovering, raising, storing, painting and covering the plant.

One is struck by the abundance of good buildings erected for and by the canal people; they extend across the Isthmus, forming at various places towns of no inconsiderable size. This remark does not apply to numerous other buildings, saloons, stores and what not, erected by outsiders in the usual mushroom style, but to the steel and iron covered permanent buildings erected by and for the company for use during construction.

A very short distance from Christopher Colon (the land end of Aspinwall), in a bight of Navy Bay, are stored the fleet of dredging machines. These are of various sizes and forms, from the Philadelphia-built leviathans, that Mr. Slaven used so successfully and profitably, down to the smaller affairs that sank more money than they raised mud. They are carefully moored, and seem for the most part in fair condition and ready for work.

At this point the dredged channel begins, and it is said that the largest dredges can traverse, without difficulty, the canal as far as Gatun, 7 miles distant, and that the channel is 15 feet deep. This statement may be received *cum grano salis*, as it is probable that the Chagres has brought down much silt since the dredging stopped, and, moreover, that the banks have largely followed their normal habit of sliding in. It is, however, not nearly of the required width, probably does not average one-fourth, so that at the best the dredgable section of the canal at the Atlantic end was about one-eighth done.

At "Monkey Hill," of historic memory, now euphonized into "Mount Hope" in the railroad time-tables, distant 3½ miles from Colon, is the first accumulation of the company's plant. It must be borne in mind that all the plant used by most of the contractors was bought and paid for by the company and rented or loaned to the contractors. This fact accounts for its present disgraceful condition, as well as for its abundance. At Monkey Hill, for instance, there are miles of side track on which are drawn up long ranks of excellent iron or wooden dump cars for standard gauge, small cars and dumps for narrow gauge (2 feet) together with any quantity of light track, made up

in short lengths so as to be portable, switches, piles of unused spikes, miscellaneous castings, parts of engines, etc. A great deal of this stuff has never been used, but was landed here preparatory to being installed. All glistens now in new paint, which, like charity, covers a multitude of sins of supply agents and accounting officers.

At Gatun (10 miles from Colon by rail) are seen the first large settlements for the contractors' uses. The river Chagres here flows in sudden curves between the Panama Railroad and the canal line; the dredging work proper ends at Gatun and the excavators begin; this part of the canal is only occasionally visible from the trains; the work upon it is comparatively light, and but for the interceptions by the bed of the Chagres, would be susceptible of easy accomplishment, but the river will soon blot out the efforts of man, and just now it is flowing with full banks.

At Lion Hill and Ahorca Lagarto the same general conditions prevail. At Bohio there is an immense accumulation of locomotives. They seem to be largely Belgian, but there are also English and French engines. The American locomotives are elsewhere. These engines look well; the brasses, including the funnel bands, have been recently polished and all neatly painted in shining black, relieved with red in good form. I am told, however, that so many of them have been robbed to obtain some interchangeable part for use on another that very few are in running order. Do not know how many are there; saw "No. 169." An immense dredge is abandoned in the river near here.

At San Pablo the line of the railroad crosses to the other side of the canal; here are more locomotives and cars innumerable. Between here and Mamei the accumulations continue; much work has been begun—*i.e.*, a large surface area has been worked over; steam diggers are to be seen standing in long rows, all newly painted. Above Mamei is a large dredge which has been carried up on the river bank in a freshet and abandoned. At Gorgona and Matachin the same conditions prevail, although there is not so much work in sight.

At Las Cascadas was a long line of locomotives and diggers which apparently had not been fitted up, but I was told that they too had been robbed to get parts to replace broken ones elsewhere.

At Empire we began to see evidences of the mighty but impotent efforts to pierce the great divide—the Culebra Hill. More locomotives, more rail by the thousand tons, more contractors' cars, more buildings and, alas! more ruin. Between Culebra Station and Paraiso the great effort was expended, and yet the

labor of years hardly shows, so small is the effect compared with the requirement. Between these two stations the summit level of the railroad is reached, and near by is the great summit cut of the canal. The works at the summit cut were in a deplorable condition; previous to commencement, a vast network of switch-backs and spur-tracks had been developed, running out of the cut on successive benches, to be used in depositing the excavated material. The weight of that material, afterward placed upon the side hill and in lateral valleys, had caused a gigantic movement of the whole formation, which is volcanic. This movement has not yet stopped; the tracks have been thrust out of position, torn apart, twisted, turned over and broken, until in places scarcely two rail-lengths remain intact. Workmen were even now employed in throwing into line and restoring the grade of the railroad at this point, before the passage of nearly every train, it being continually pushed out of place from the same cause.

When it is remembered that this is only the commencement of the effect, and that the Culebra cut has only been scratched over on the surface, one can scarcely form an idea of the chaos that would follow if greater efforts should be made to take out this cut. The railroad crosses this cut near its southern end, and a diversion was begun near the summit, bending more to the westward so as to make room for the canal. The new line was ready for the rails when the canal work stopped.

Just north of where the present line crosses the axis of the canal, which it does upon an embankment, is a pool formed by the dammed-up water. In the depression which the pool occupies is collected a miscellaneous group of machinery that is a fair illustration of the lack of thought prevailing among those in charge of this work. In this group were steam excavators, dredges, steel lighters, steamboats of the Seine type, for transport purposes at a future day, a large iron pontoon or sectional boat, construction cars, track, switch-points and all sorts of stuff.

A huge mud-digger, with high wooden tower, conveyor and bridge leading over the railroad embankment, had been set up in this depression and started just before orders had been received to stop the work, and a small quantity of material had been moved. It was fortunate that the amount was not greater, because the bridge was placed so as to discharge into a lateral valley close to the canal line; and the first heavy rain would not only have sent it into the canal excavation a short distance below, but it would in all probability have, by its weight, started a movement in the formation similar to that observed on the other side and above referred to.

Vast preparation was made for this master-work at Culebra.

Houses and quarters and offices *ad libitum*; electric lighting on the works and in the village as well; shops and sheds and all sorts of stores and machinery. I saw a huge pyramid of iron track-spikes that had been removed from their kegs and stacked up without cover, enough to lay many miles of track, and everything was in like profusion. It is safe to say that if only one-fourth of the preparation had been made, and made properly, at least twice as much real work could have been accomplished; but it is my deliberate judgment that even with the most rigid economy and wisdom of direction, the natural conditions are so unfavorable that the Canal Panama cannot be finished for any sum that can be secured.

Beyond Paraiso, down the Pacific slope to the Bay of Panama, very little has been done. In the bay itself, some distance down ($2\frac{1}{2}$ miles) a very good shop and depot have been established and a branch of the railroad built to it. Some dredging has been done for show there, but no attempt to blast and remove the coral reefs between there and the shore.

No disposition of the vexing Chagres had been decided on—this question is as vital as ever or more so.

The "iron-locks," of which so much has been said, seem to have been devised more with a view to control the flow of the stockholder's imagination than to do any service in the canal. In fact it is said that beyond making a nice scheme on paper and placing a contract for certain of the locks, no change on the work or other provision was ever made for them. They would not only not solve any difficulty, but their use would entail an enormous expense of operating, as water to supply the summit level would in certain seasons of the year have to be raised by pumping. It can hardly be supposed that they were ever seriously contemplated."

The French Commision referred to in the above extract subsequently visited the canal and spent several weeks in an exhaustive examination. Such rumors as have reached this country as to the probable nature of their report (which is not yet promulgated) indicate that they could not recommend resumption; but whether they do or not, the Canal Panama is virtually abandoned and cuts no figure in the inter-oceanic problem of to-day.

During the period which has witnessed the end of the Panama effort, the development of the Nicaraguan project has gone slowly but steadily forward. The location and plans adopted in 1885 have been adhered to in general, although there have been some notable improvements in the detail of the final location. Rock-

filled dams, instead of masonry or concrete, have been adopted, and some alterations in the development and distribution of the locks have been found advantageous. Through the Deseado-San Francisco Divide a considerable saving in quantities has been made by a slight change of line which now follows the course of the Rio Limpio instead of the Arroya. As a very full authentic description of the entire route appeared in the *Engineering News* of September 14th, 1889,* which has been extensively reproduced, and as other technical journals have also described the line, its principal features are doubtless so familiar to members of the Club that they need not be dwelt upon here.

When the writer visited Nicaragua in October, 1889, the final definition of the lines was about completed, and a large staff of engineers was busily employed in making detail surveys for dams, locks and embankments; in locating the railroad system to be used in construction of the canal; in constructing the telegraph line, since completed, extending into the interior and connecting with the cable lines to New York; in prospecting with diamond drills in the big cut; in preparing for the water supply for the construction forces; in laying out the new town of "America" at the Atlantic terminus, and in tentative work of various kinds connected with the harbor.

They were also employing steam snag-boats in improving the navigation of several small rivers which are to be utilized for conveying plant, material and men to various points of attack, and, in short, carrying on preparations for the great work to come, in multitudinous details.

The clearing, for such parts of the dredgable section as are above water, of all standing timber, had been begun.

A number of heavy steam pile-drivers were in position, ready to begin operations on the temporary breakwater; and a large quantity of creosoted pine piles had been assembled.

It is, of course, hardly possible to proceed with any work of magnitude in a foreign country without encountering classes of delays both physical and political that would not be met at home and the Nicaragua Canal has not escaped in this regard.

It is not necessary or appropriate to enumerate here the political

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* See also "Some Engineering Features of the Nicaragua Ship Canal," by J. Foster Crowell. Proceedings of Engineers' Club, Vol. V, No. 4.

complications that for a time interfered with the progress of the work, nor to say more than that they were largely based on territorial considerations and at length were adjusted in a manner satisfactory to the canal interests. As a consequence, although the formal ceremonies of "digging the first spadeful," in which the writer had the honor of participating, occurred on the 22d of October, 1889, it was not until about the first of the present year that work was definitely begun on the temporary breakwater at Greytown.

Mr. A. G. Menocal, C. E., member of the Club, the chief engineer of the canal, as well as its leading spirit and promoter, past and present, has kindly furnished me with the accompanying information concerning the breakwater and diagrams (see Plates I and II), showing the effect produced by the work already done. The temporary breakwater, which will form a part of the permanent structure, is necessary to provide entrance for vessels loaded with heavy plant and stores for the prosecution of the work, into the inner harbor and to the railroad wharf.

The next step to secure this object is the dredging of a channel 20 feet in depth, across the bar and through a sand-spit to the inner harbor. This work has been contracted for and will be begun as soon as the dredging machines can reach there.

Contemporaneously with this, a contract has been awarded to C. M. Treat, of Chicago, to construct 18 miles of railroad from the harbor along the canal route to the eastern end of the Deseado Divide. These preliminary steps are necessary to prepare for the attack in force; the forethought they evince is in marked contrast to the course adopted at Panama.

There is a tendency or a temptation to name in advance a period for the completion of any work. Rapidity of construction is often held up not only as evidence of great ability on the part of all concerned (if attained), but as a moral obligation. As a matter of fact, it is oftener a crime, and in a work of this character deliberate progress, but always progress, should be the desideratum. It will not do to repeat the vainglorious boasts made at Panama and to say that the Nicaragua Canal will be an accomplished fact in five years, or in seven years, or even in ten years. If all goes well, the vessels of the year 1900 will be using it, in all human probability; but the world should not expect more

than that it shall be built wisely, economically, and so perfectly as to last for all time. To secure such a result, a few years more may well be expended.

The most important as well as the most interesting part of the preliminary work is the harbor entrance at Greytown; and although, as stated elsewhere, the construction of the temporary breakwater has only recently been begun, the results already observed are so significant and favorable as to justify a brief description.

What is called the inner harbor was in former times an open roadstead, two miles or more in width, and of ample depth for any vessels. This is now separated from the ocean by a sand-spit a few hundred feet across, extending nearly the entire width of the harbor. At the eastern side is a natural entrance, navigable for light-draft vessels during most seasons. Outside the sand-spit and parallel to it is the Greytown Bar. The sea, in breaking on the bar, becomes loaded with sand, which is thus continually and perpetually being carried to, and deposited on, the spit; but the trend of the sea, being usually inclined to the beach, also undermines and cuts away the outer edge of the sand-spit and carries its material farther up the coast, and the result is to maintain approximately the same width of the spit from year to year. The canal entrance is to pass through the spit near the western side of the harbor. The accompanying map (Plate I) shows a portion of the spit, the entrance and the breakwater projecting into the Atlantic at right angles to the beach and almost due north; the trend of the sea is, roughly speaking, from the northeast. The office of the breakwater is primarily to prevent the sand from being carried across the entrance and to cause it to be deposited east of the pier. The theory of the plan is that, the waves being relieved of the sand, the formation of the sand-spit west of the pier will cease, and, by extending the pier to deep water, and thus increasing the area of deposit on the east, the sand deposit will be prevented from occurring to an injurious extent within the limits of the entrance for a long time to come, and can be readily removed by dredges working within the shelter of the breakwater. The pier, of piles and brush, forming the temporary breakwater, is to extend out 1,700 feet to the point where the permanent stone structure will begin. This pier is 40 feet in

width, consisting of six rows of creosoted pine piles driven by the water-jet process. The piles in the outer rows have spaces of ten inches between them; the inner rows are in pairs every eight feet, and so disposed that the lateral horizontal timbers supporting the platforms pass between them. The pier is filled with brush weighted with stone.

Work was begun on January 7th, 1890, and on March 17th had advanced 600 feet, the date of last advices,* the daily progress then being about 10 feet. (See Plate I.)

Cross-sections showing the original beach were taken at intervals of fifty feet, east and west of the pier, on lines parallel to the pier, and levels on the same sections were taken every week for the purpose of noting and recording the effect.

The map gives the position of two typical sections, *ab* and *cd* (see Plate II), east of the pier, showing how far the beach had advanced on March 3d and March 17th, respectively; while *cd*, west of the pier, shows that on March 3d much of the spit had been destroyed and carried away, while on March 17th it had completely disappeared at that point.

The line of dash and dot, extending along the beach, shows the new beach line which runs out in the old beach about five hundred feet away, and makes an average advance of about 50 feet per month. It is obvious that this rate of advance will rapidly decrease as deeper water is reached and as the effect is distributed farther to the eastward.

The pile-pier will be carried out to a depth of three fathoms; and the remainder, or stone portion of the breakwater, to a depth of five fathoms.

The double curves shown as defining the harbor entrance indicate the lines of top and bottom of the submerged slopes to secure 30 feet of water.

With this explanation the map and sections will be easily understood. They show the correctness of the theory advanced, and to a degree far surpassing the most sanguine anticipations of its designer.

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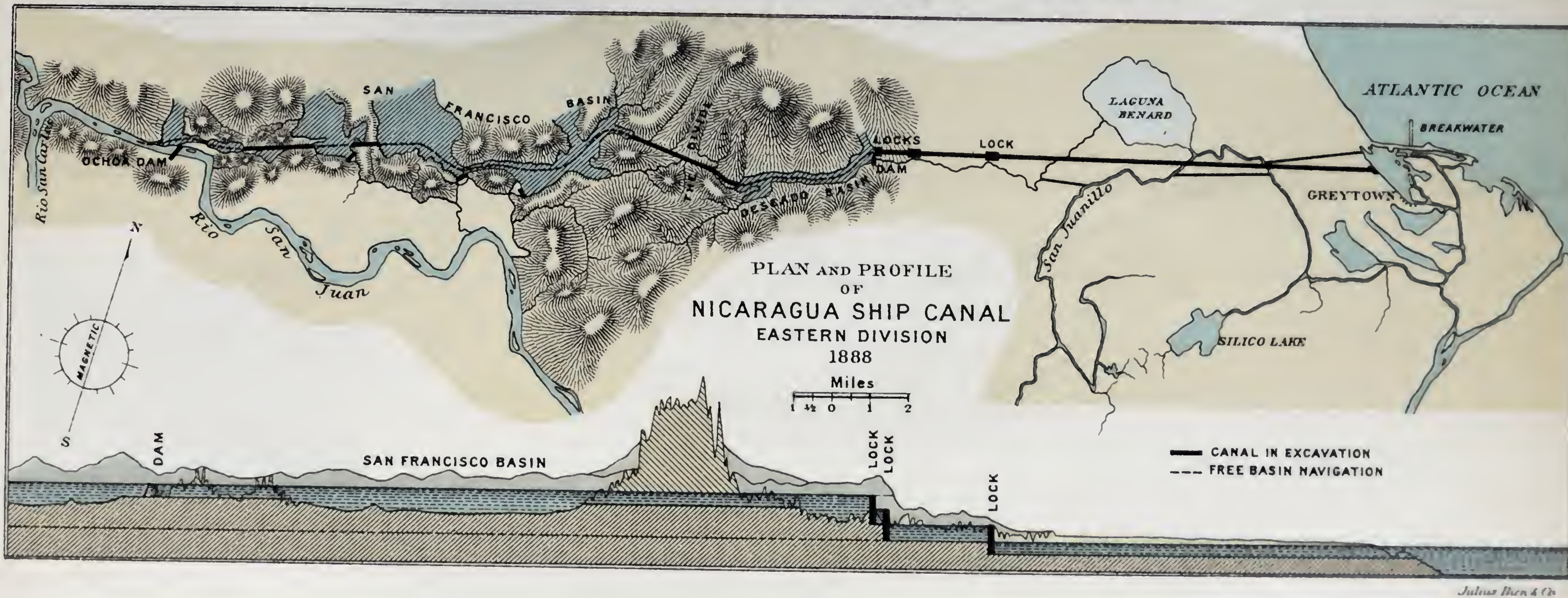
* During the time which has intervened between the reading of the paper and the issue of this number of the Proceedings, the work on the breakwater has proceeded, and the success of the plan is already established; for it is a matter of record that an ocean steamer drawing fifteen feet of water has safely passed into the inner harbor through the new channel which is now being deepened to twenty feet by the identical dredging machines that were formerly used by Slaven on the Panama Canal.—J. F. C.


PLAN AND PROFILE
OF
NICARAGUA SHIP CANAL
EASTERN DIVISION
1888
Miles
1 ½ 0 1 2
ATLANTIC OCEAN
BREAKWATER
GREYTOWN
LAGUNA BENARD
SILICO LAKE
San Juanillo
LOCK
LOCKS
DAM
DESEADO BASIN
THE DIVIDE
SAN FRANCISCO BASIN
OCHOA DAM
Rio San Carlos
Rio San Juan
MAGNETIC
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DAM
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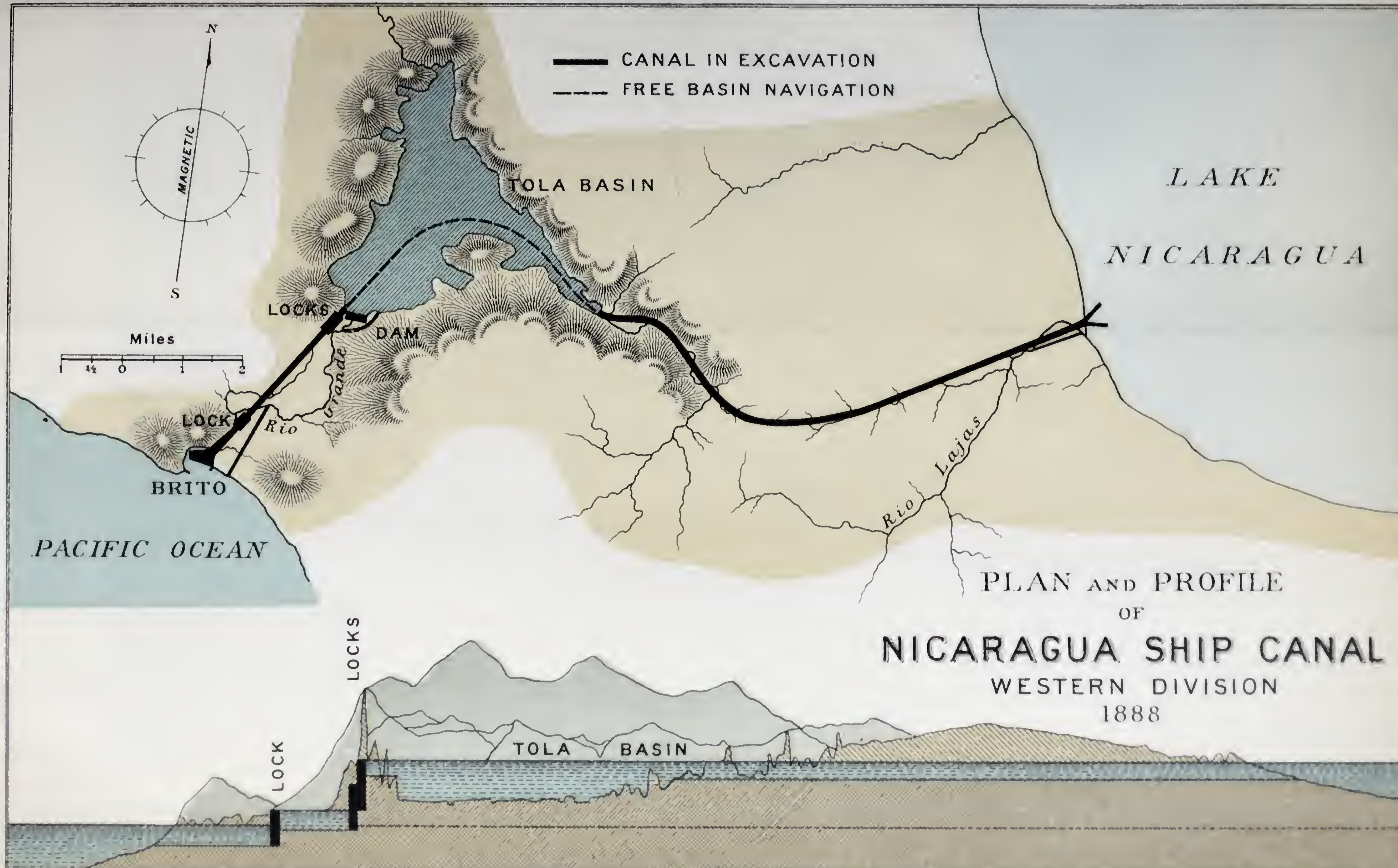
LOCK
LOCK
LOCK
CANAL IN EXCAVATION
FREE BASIN NAVIGATION
Julius Bien & Co.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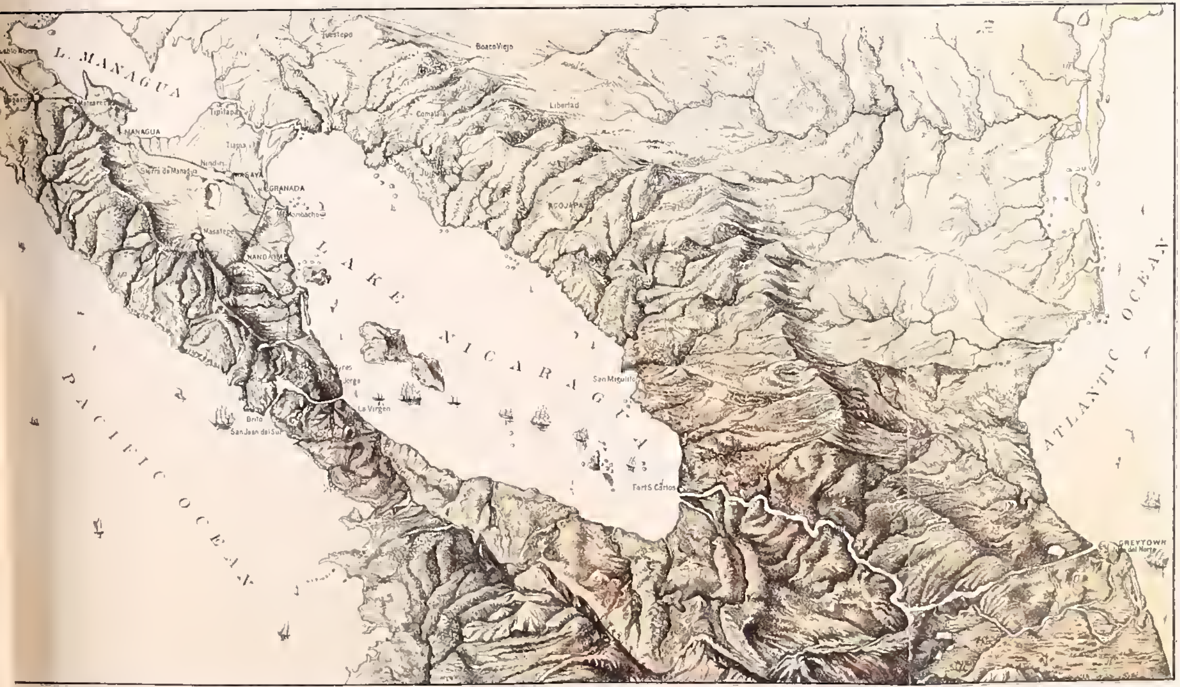
LAKE NICARAGUA
TOLA BASIN
LOCKS
DAM
Rio Grande
LOCK
BRITO
PACIFIC OCEAN
Rio Lajas
PLAN AND PROFILE OF NICARAGUA SHIP CANAL
WESTERN DIVISION
1888
LOCKS
LOCK
TOLA BASIN



THE NICARAGUA CANAL

PLATE I

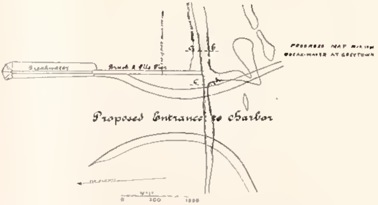
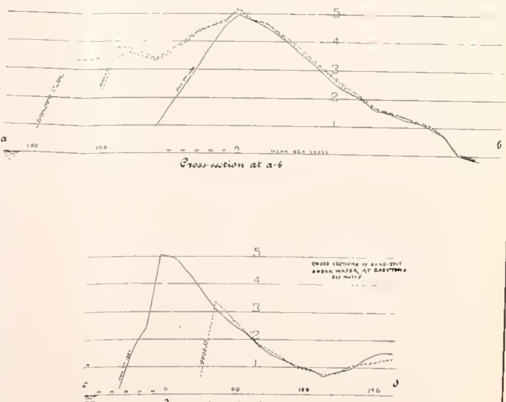


PLATE II.



Cross-section at a-b

Cross-section at c-d

NOTES AND COMMUNICATIONS.

CONVENTIONAL SIGNS FOR BRIDGE RIVETS.

Business Meeting, March 2d, 1889.—The Secretary presented, for Mr. Samuel Tobias Wagner, a copy of a circular containing Osborn's Code of Signs for Bridge Rivets, with a list of thirty-five large establishments that have adopted this code as standard.

In this code a countersink is indicated by two lines crossing at right angles through the center of the circle representing the rivet, and a flattened head by one or more vertical lines drawn through said circle. A blackened circle of smaller diameter, in the center of the larger one, indicates a field rivet.

The position of the cross or stroke with respect to the circle (inside, outside or both sides) indicates the position of the countersink or flattening, thus:

If it crosses the circle without appearing beyond it, the work is "inside."

It it crosses the circle and extends beyond it, the work is on "both sides;" and

If it appears only outside of the circle, the work is "outside" only.

Finally, the height of the flattened heads is indicated by the number of vertical strokes, each $\frac{1}{8}$ inch of height of head being represented by one stroke.

Any combination of field, countersunk and flattened head rivets liable to occur, may be readily indicated by the proper combination of these signs.

Regular Meeting, April 20th, 1889.—The Secretary presented, for Mr. Samuel Tobias Wagner, a copy of a letter written by him to *Engineering News*, suggesting that in order to avoid ambiguity in Osborn's Code of Signs for Bridge Rivets (above mentioned) the following modifications should be made in its terminology:

1st. In every case where the word "Inside" is used, modify it by the parenthetical clause ("Reverse Side").

2d. In every case where the word "Outside" is used, modify it by the parenthetical clause ("Side Shown").

3d. For the flat head $\frac{1}{8}$ inch high, substitute "Flattened to $\frac{1}{8}$ inch high (countersunk and not chipped);" for "Flattened to $\frac{1}{8}$ inch high, or countersunk and not chipped."

ENGINEERING NOTES FROM ENGLAND.

Regular Meeting, March 2d, 1889. The Secretary read the following letter from Mr. John C. Trautwine, Jr.:

Our trip on the "City of New York," leaving New York September 20th, was, like her three former trips, a disappointment. Although designed, it is said, with a view to beating all previous ocean records, including the Etruria's fast run of six days and two hours, she was about eight days in making the passage from land to land. This can hardly be chargeable to the rough weather, although the "Adriatic," of the White Star Line, which left New York thirteen hours before us, did not reach Liverpool until several hours after we were in.

It was explained that our slowness was due, not to any deficiency in the engines proper, but to the inadequacy of the circulating pumps. This, it was said, would be remedied before she made her next trip westward, which, I understand, she accomplished in six days and fifteen and a half hours from land to land, which is very good time, though she is said to be under contract to do much better still. It was fortunate for the passengers that she is a twin-screw boat, for owing to the inefficiency of the condensing apparatus, her starboard engine was idle during much of the time and running quite slowly during the rest. If this had been her only engine, our voyage would, of course, have been greatly prolonged, while, as it was, we limped along after a passable fashion by means of the port screw.

The "City of New York" is an admirable passenger boat, not only by reason of her very superior appointments, but also on account of the height of her promenade deck (and especially of her bow) above the water, this feature serving to keep her deck dry and rendering it possible for passengers to be on deck during the day in nearly all kinds of weather, a consideration of the first importance to those who are subject to slight indisposition when at sea.

Among the many novel features embodied in the "City of New York," that which has perhaps excited most curiosity is her so-called "rolling chamber," or, more properly, anti-rolling chamber, designed to diminish her lateral rolling. This device, although it has been employed upon *war* vessels in order to facilitate accurate firing, and thus enable men to mangle and murder one another with greater neatness and dispatch, is, I believe, a novelty in its present application to the *comfort* of men.

It consists of a chamber or tank extending across the lower part of the vessel nearly amidships. In the "City of New York" this chamber is contracted, midway between the sides of the vessel, not by an upward bulging of its floor, as shown in the *Railroad Gazette* of December 16th, 1887, but by a sharp curvature of either its aft or its forward end wall, as seen in plan, which brings this wall to within a few feet of the opposite one and reduces the length of the chamber, over the keel, to say about one-third of that at the sides. The chamber (when "the powers that be" consider it necessary to use it) contains a large quantity of water, which rolls from side to side as the vessel rolls, but is supposed to be delayed, on each passage across the ship, by the contraction in the middle, so that it always pours itself over to that side of the ship which is coming upward, thus tending to diminish the downward roll of the other side.

I regretted (indeed nearly all the passengers regretted) not having an opportunity to test personally the efficacy of this device. There were times when the passengers were unanimously of the opinion that the vessel rolled—unmistakably—but the captain and other officers assured me that she had not rolled, but had merely "lurched," moving in a combined rolling and pitching (fore-and-aft) way, against which the rolling chamber is said to be ineffective. Therefore no water was run into the chambers. Indeed, they had not been used at all, except when the vessel was making her trial trip.

Possibly the captain or engineer of such a vessel, anxious to make the best time possible, has difficulty in finding a sea that renders it advisable to use the rolling chambers; for such use must, of course, increase the immersion and perhaps diminish the speed of the ship.

Owing to the great range of the tide (from 20 to 27 feet) in the Mersey, opposite

Liverpool, the ocean steamers drop anchor in mid-channel and transfer their passengers to a small side-wheel steamer called a tender. (By the way, nearly all the small steamboats hereabouts have side-wheels.) The tender again lands the passengers not upon terra firma, but upon an immense platform supported by plate-iron pontoons, and floating at a distance of some 100 feet from the shore, with which it is connected by eight heavy plate-girder bridges, accommodating vehicles and foot-passengers. These bridges are hinged at their ends, allowing the floating platform or "landing stage," as it is called, to rise and fall freely with the tide.

The landing stage itself is 2,200 feet (or five-twelfths of a mile) long, by about 80 feet wide, and is said, by the guide books, to be the largest in the world. It affords landing facilities not only to the tenders of the ocean steamers, but also to numerous river-lines, including the ferries which run from Liverpool to Birkenhead and other towns on the left bank of the Mersey. Upon the landing stage are the ticket offices (or booking offices as they are called here) of these various lines, together with restaurants, luggage rooms, etc.

The casual observer, I think, gets his best impression of the world-renowned docks of Liverpool from the deck of the tender as it nears the landing stage, especially if the tide is low, thus exposing to view their massive masonry, which contrasts strangely with our recollections of wharf structures as we see them at home. After landing, unless he has an experienced and intelligent guide, and some hours to spend in examining the docks, he is apt to see but little of them, and that little to not very good advantage; for they extend for eight miles along the river front, and the stranger is apt to take many idle steps in threading his way among them. Besides, with the exception of the dry docks when empty, the hasty visitor traveling along the edges of the docks may find that, as at Niagara, "there's nothing to see but water."

The river-front street of Liverpool, just behind the docks, and between them and the scarcely less renowned warehouses, rejoices in a veritable tramway, consisting of broad rails laid a half inch or so below the level of the adjacent paving. The vehicles using it have very stout wheels of rather small diameter, but of a tread nearly equal to the width of the tram-rail (I should say about four inches), and are mostly heavy drays and trucks for merchandise, but there is also a line of passenger tram-cars or omnibuses. These ponderous street cars turn off from or on to the track at pleasure, much to the surprise of the newly-arrived Americans among their passengers.

The Liverpool and Birkhenhead Railway tunnel (opened in 1884) is in full, *very* full operation. The trains seem to be always well patronized and often crowded. At the Liverpool end passengers have a choice of three means of access to, and egress from, the tunnel. First, by a long sloping subway or approach tunnel; second, by a stairway, still more tiresome, if possible; and third, by an enormous "lift," which must certainly accommodate over 100 persons. The last-named is, of course, the popular route. It is needless to say that it is slow.

Along the railway between Chester and Liverpool, one catches glimpses of the work (still in its early stages) on the Manchester Ship Canal. At Manchester I had the pleasure of meeting Dr. Albert R. Leeds, of Stevens Institute, Hoboken, formerly of the Philadelphia High School, who has within recent years made a number of analyses of our Schuylkill water for the Water Department. I found him engaged in devising ways and means for purifying the Irwell and other streams thereabouts, which are filthy to an extent that our much-abused river, at its worst, has never dreamed of. They suggest rather Cohocksink Creek and Gunner's Run.

While the London and North Western is the most direct route between Liverpool and London, the Midland undoubtedly is, as it claims to be, the scenic route. Its northern portion runs by sharp grades through a very remarkable and romantic limestone district, where the location must have been very difficult and the construction expensive.

Railway construction here is, as you are aware, generally of a more massive and "come-to-stay" character than with us. Slopes that at home would be left to take care of themselves, are treated liberally to retaining walls, especially in the suburbs of cities where the high cost of land renders such treatment true economy. Brick and stone arches abound in localities where we would use light wooden trusses.

Among interesting features on some of the roads here, I notice sign-boards giving the distances at every quarter mile, and others showing each change of grade. The latter have two arms, pointing in opposite directions along the road, slanting up or down to indicate which way the grade slopes, and marked with the grade.

The rails used here are mostly of the "bull-head" type, in which the broad flat flange of the American rail is replaced by a rounded bulb nearly resembling the head. The rails, instead of being merely spiked to the cross-ties, as with us, rest, at each tie, in cast-iron chairs bolted to the tie, and are held in place in the chairs generally by wooden wedges driven on the gauge side of the rail. With a rail thus amply secured along its entire length, the rail-joint must be a less vulnerable point than with us. The English use a narrow and short suspended fish-plate, and also a sort of sleeve-joint somewhat resembling two angle bars joined together underneath the rail, the lower part of the joint being rolled to fit the rounded base of the rail. This joint also, like the fish-plate, is suspended.

The Great Western Railway has on its main line not only the standard gauge of 4 feet 8½ inches, but also a third rail for the 7-feet gauge, many of its carriages on through trains being still of that gauge. On these portions (at least near London) they use the old-fashioned inverted U rail, once largely used on the Camden and Amboy Railroad. It rests upon wooden shims about five-eighths of an inch thick, four inches wide and six inches long, laid transversely and close together upon longitudinal wooden sleepers, to which the rail is bolted, the bolts passing through the flanges of the rail at intervals of about three feet except near the joints, where there are three or four pairs of bolts within, say, a couple of feet. At the joint, the two ends of the abutting rails rest upon an iron plate about a quarter inch thick and six inches square, let into the shims, and beyond this there appears to be no special provision for the joints.

The longitudinal sleepers are held in place by transverse wooden struts about 3 x 6, and ten feet apart, notched into the sleepers and secured to them by strap bolts.

There is great diversity in the types of passenger engines here. They have anywhere from one to three pairs of drivers, of diameters say from four feet to seven feet; front trucks, rear trucks, trucks front and rear, or no trucks at all; cylinders inside or outside, horizontal or inclined; tenders or no tenders. As Mr. Dean remarks, in comparing American and English locomotives, this very diversity "indicates greater progress. The American passenger locomotive presents the unique spectacle of being almost identically the same all over the country (as if exactly the proper design had been found), whereas in all other machinery there is endless variety."

There are some features, however, in which the English locomotive knows no variety—there is never a bell, or a head-light, beyond an occasional and merely ludicrous bull's-eye, and seldom any adequate protection for the engineer and fireman. In these respects it may be said of English locomotives, as of English cars and some other English matters,

> Time writes no wrinkles on thine azure brow—
> Such as creation's dawn beheld, thou rollest now.

It has been urged that the English railway "carriages," arranged, as they are, like four or more funeral hacks placed back to back, have this advantage over our long American "cars," that they are more readily emptied and loaded at stations, so far as the mere stepping in or out of passengers is concerned, though even here it must be remarked that it takes time to wedge one's way through four interlocking pairs of knees, and it is best not to undertake the feat "until the train comes to a full stop in the station." But when we consider the hopeless confusion that always obtains upon the arrival of a train at a station, the running to and fro of would-be passengers looking for room in a compartment of their particular "class," this advantage is seen to be largely if not wholly imaginary. I am sure the "underground" trains in London, for instance, occupy much longer time at stations than do the trains of the elevated railroad in New York.

London, perhaps, excels all other great cities in the smoothness and cleanliness of its street pavements. In the more densely crowded parts of the city wooden blocks and asphalt are used, while a little farther out we come to Belgian blocks, and still farther to a concrete of small stones apparently an inch or two in greatest dimension.

The wood and the asphalt are the perfection of smoothness, the latter in the evening reflecting the glare of the street lamps after the manner of a skating park. But this very smoothness, which makes riding a luxury for the passenger, is a source of uneasiness to the horse and the driver, for even in dry weather these splendid pavements are slippery, while the least dampness renders them shockingly so, horses sliding along on all-fours for several feet in trying to stop. To remedy this, small pebbles are strewn over the cartway, and these, being broken and ground into the surface by the traffic, tend to roughen it somewhat. This, however, seems only partly efficacious.

Through the courtesy of Mr. Alexander Fraser, Engineer of the Grand Junction Water Works Company, one of the eight companies supplying London with water, I have been permitted to visit some of the works of that company, which supplies an area of irregular shape extending southwestwardly from Trafalgar Square about fourteen miles to Sunbury, on the north bank of the Thames above Hampton, and averaging about three miles in width. This area includes the neighborhoods of Piccadilly, Hyde Park, Paddington, Bayswater, Notting Hill, Shepherd's Bush, Acton, Ealing, Hanwell, Brentford, Isleworth, Hounslow, Twickenham, Teddington, Hampton and other villages. I am indebted to Mr. Fraser, also, for much of the following information :

The company has about 395 miles of mains, varying from 3 to 30 inches in diameter, 262 miles of which are constantly and the remainder intermittently supplied, and serves an estimated population of 485,000 persons, occupying about 54,000 houses, 42,000 of which have constant supply. It pumps all of its water (averaging about 18

million U. S. gallons per day) from the river Thames at Hampton, on the north or left bank, about two miles above Hampton Court and 24 miles (as the river winds) above London Bridge. At Hampton are seven pumps, aggregating 1,149 horse-power. These pump the water to a height of 150 feet, from which a portion goes directly to the low-level districts supplied by the company, while the remainder flows through a 33-inch main to the reservoirs, filter-beds and pumps in the station near Kew Bridge in Brentford, on the north bank, about 11 miles below Hampton, as the river winds. Here the water, after passing through filter-beds, is pumped directly to the consumers, one main running due north about two and a half miles to a reservoir at Ealing, a suburb of 16,000 inhabitants, about nine miles west of St. Paul's Cathedral; while another main runs about five miles west by north to reservoirs at Campden Hill in the extreme western part of the built-up portion of the city, and to a covered reservoir of 7 million U. S. gallons at Shoot-up Hill, Kilburn, three miles farther north and 250 feet above the Thames.

The reservoir at Ealing is about 175 feet above the works at Kew and about 70 feet above those at Campden Hill.

The works at Hampton are arranged for two different purposes:

(1) For pumping water out of the river and supplying it, unfiltered, to the works at Kew Bridge.

(2) For the direct supply of filtered water to all the rural districts on the low ground between Sunbury and Notting Hill.

The plant for supplying unfiltered water to the works at Kew Bridge consists of two conduits bringing the water from the river into two deposit reservoirs, from which it flows to the pump wells of three direct-acting engines, capable of lifting 14½ million U. S. gallons per day into a stand-pipe about 150 feet high, from which the water passes by a line of 33-inch pipes to the reservoirs at Kew Bridge, a distance of seven and a half miles.

For the supply of the low-level districts between Sunbury and Notting Hill there is a storage reservoir of 10 acres surface and a capacity of 54 million U. S. gallons, five filters constructed of sand and gravel lying on a layer of small agricultural pipes, and a covered reservoir, composed entirely of concrete, and containing 3½ million U. S. gallons of filtered water. From this covered reservoir the water passes to the pump wells of two rotative engines of 150 horse-power each, made by James Watt & Company, of Soho, Birmingham. These engines pump the water, against a head of 150 feet, through a line of 30-inch pipes, connected to the supply mains of the large district supplied.

When the river is much disturbed by floods, all the water taken at Hampton is received through a special intake, from which it flows, through two vertical strainers (one coarse, the other fine), into a line of 24-inch open-jointed stoneware pipes, laid with a slight fall and extending about half a mile inland, or at right angles to the river. This line of open-jointed pipes rests upon the top of a natural bed of sand and gravel.

The muddy water, escaping through the open joints, passes through the gravel bed to a second and double line of similar open-jointed pipes, laid parallel to the first, but five feet lower and about 150 feet away horizontally, which lead the water, now comparatively clear, to the pump wells of two horizontal pumping engines. These lift the water into the reservoirs already mentioned for supplying the high-level pumps

at Kew Bridge and the direct low-level service. The water for the latter service has still to pass through the regular filter-beds, the same as when the river is comparatively clear, the gravel bed being regarded merely as a strainer for removing the grosser impurities. As much as 14½ million U. S. gallons per day have been pumped through the gravel beds during times of flood, when the water was in a very turbid condition.

To meet the growing demand for water in the immediate neighborhood of Hampton, which is all at low level, a new engine of 100 horse-power is being erected to give an independent supply through a line of 12-inch pipes. This engine is being supplied by Messrs. Hathorne, Davey & Company, of Leeds, and contains several important improvements.

When this engine is ready to work, the Grand Junction Company will have five different zones of height, each with a separate supply, and no doubt this is the best possible arrangement where the levels to be supplied vary as much as 200 to 250 feet, as in their case.

As there are eight companies supplying London and its environs, each having probably quite as large a variation in levels of supply, it will be readily understood that as a whole the proper supply of this vast aggregation of towns must be a very complicated business.

I recently had the pleasure of examining the works at Kew Bridge, in company with Mr. Goodman, the Superintendent. These works were begun about fifty years ago, after it had been decided that the water pumped at Chelsea, about nine miles farther down stream, was becoming unfit for use, and were employed in pumping water from the river until about 1852, when changes in the sewerage arrangements of London rendered this site in turn unsuitable, and the Hampton pumping station was established.

The water from Hampton is now received at the Kew Bridge works in two reservoirs, of about 16 million U. S. gallons united capacity. These were originally intended as settling reservoirs and used as such, but the quantity of water now passed through the works is too great, and the dimensions of the reservoirs are too small, to allow of their serving efficiently in this capacity. From the higher to the lower receiving reservoir the water ordinarily falls over a tumbling dam set with fire bricks, which are placed on end and about eight inches apart. This, of course, is intended to secure aeration.

From the lower reservoir the water passes to the filter-beds, of which there are seven, having a united area of 8½ acres. The filtering material is sand and gravel, increasing in coarseness from the top downward. In the older beds, square culverts of common bricks with open joints, and showing three bricks in a cross-section, ran along the bottom of the bed through the lower gravel stratum at intervals of about 10 feet, and through these culverts the water ran to a central culvert of larger section, built in bricks and mortar. All the culverts were provided with vertical cast-iron ventilating pipes leading up to above the water surface, and placed at intervals of about 20 feet.

In later forms these small square or box culverts of brick were replaced by open-jointed rows of drain tiles, laid close together, side by side, over the entire bottom of the bed; while in renewing the bottom of one of the oldest beds (a work which is now going on) both brick culverts and tile-drains are dispensed with, the bottom

layer of the bed being composed of stones, say from 3 to 6 inches in largest dimensions, the interstices between these being relied upon to carry the water to the central culvert.

To cleanse the filtering material, it is thrown into an open cast-iron cylinder about three feet high and seven feet diameter. A few inches above the bottom of the cylinder is a false bottom punctured with holes about an eighth of an inch in diameter, and two inches between centers. The sand to be cleansed rests upon this false bottom. Water, under pressure, is led from a main into the space between the two bottoms, and, of course, passes upward through the minute holes in the false bottom, and through the sand above, very much as the air passes through the molten pig iron in a Bessemer converter. A number of men stand around the cylinder stirring the sand with iron bars. The water, passing upward through the sand, soon fills the cylinder and flows off freely around its upper edge, carrying with it the impurities deposited in the sand during the process of filtering. The washing is continued until the water comes off perfectly clear. Filtering has been carried on at these works since they were opened about fifty years ago.

From the filter-beds the water passes into a covered reservoir one and a half acres in extent, and from this directly to the pump wells.

There are seven Cornish pumping-engines, with an aggregate of 1,106 horse-power. They pump into a stand-pipe about 175 feet high. From the stand-pipe the water passes to the mains through a second vertical pipe, which communicates with the main stand-pipe about two-thirds way up. In the case of breakage in the mains, there is thus preserved a head of 100 feet for the engines to work against.

The reservoir at Mount Park, or Hanger Hill, Ealing, already referred to, was built in 1884, and has a capacity of three and a half million U. S. gallons. It is used chiefly for the supply of Ealing itself, a check valve in the pumping main bringing the reservoir into play when the pressure from the pumps at Kew Bridge falls below a certain point.

Of late years the demands of the town portions of the company's district, during the London "season" of May and June, have grown to such an extent as seriously to tax the capacity of the pumps at Kew Bridge. A reservoir with a capacity of sixty-three million U. S. gallons was, therefore, built upon a site immediately adjoining that of the much smaller Ealing reservoir. It has just been completed and connected with the Kew Bridge Works by a thirty-inch main, two and a quarter miles in length. This new reservoir will be filled at leisure during the slack demand of the winter months, and is intended to come to the relief of the pumps during the busy summer season, supplying by gravitation the extra demands of the town portion of the company's district.

The water companies are bound to supply water free of charge for extinguishing fires, and the matter of fire-plugs is one in which London seems to be far behind our proverbially dormant city, the practice here reminding me of a paper by our past President, Mr. Graff,* in which he described the fire-plugs at one time used in Philadelphia. The fire-plug, as here used to-day, takes its name from a veritable tapering wooden plug, driven into the open upper end of a short vertical pipe, which extends upward from the top of the main to the surface of the street. A short dis-

* Proceedings of Engineers' Club of Philadelphia, Vol. IV, No. 1, March, 1884, p. 26 (Illustrated).

tance from this plugged pipe is a similar one, without a plug, but containing the stem of a valve in the main. The tops of both pipes are about flush with the street paving, while that of the plug is a few inches below it. When a fire breaks out, the "turncock," who is supposed to be hovering around, is sought for, and, if found, he comes with his key, and at first turns off temporarily the supply, in order that the fireman may safely loosen and remove the wooden plug and thus obtain access to the main, which he does by "jabbing" into the top of the plug the pointed end of an iron bar, which he then shakes from side to side, thus loosening the plug, which is then withdrawn. A box or dam of canvas, stretched upon a frame made of half-inch round bar iron, is then placed over the top of the pipe. This dam contrivance is about eighteen by thirty-six inches by fifteen inches deep, is open at top, and has in the bottom a circular hole an inch or two larger than the diameter of the pipe in the pavement. The turncock then turns on the supply again, and if nothing happens to shift the dam from its place, some of the water from the main fills it, and it thus forms the reservoir from which the engine draws its supply, the intake end of the suction pipe being simply laid in the dam.

As the supply from the main must always be kept in excess of the demand from the engine, such of the company's dearly-pumped water as happens to find its way into the box from below escapes by flowing over its top, except, of course, the portion thrown upon the fire by the engine.

The great wastefulness of this process is leading the companies gradually to introduce the fire *hydrant*, especially in the densely-built parts of the city, and around such premises as those of London's rather unsuccessful imitation of our Wanamaker, Whiteley, "the Universal Provider," who has lately suffered from repeated fires, and whom the insurance companies will not now touch at any price.

The old city of London proper (a comparatively small district) has been completely furnished with fire hydrants for some time. They have double nozzles, and are of very superior construction. They were made by Messrs. Simpson & Company, of the Grosvenor Works, Pimlico, London, who also make the hydrants now fixed in other parts of the metropolis.

Where the pressure in the main is sufficient, a contrivance called a stand-pipe is sometimes used in the absence of a fire engine. It consists simply of a vertical pipe, tapered below to fit into the pipe in the pavement, and furnished at top with one or two tapped nozzles, to which hose may be attached. One would suppose that a similar arrangement might be substituted for the barbarous dam for supplying the fire engines.

With the exception of the small district known as the city proper, which is under the control of the Loid Mayor and Corporation, London, within the metropolitan area, is managed for certain purposes by the Metropolitan Board of Works. Outside that area each suburban village has its own local board, which has charge of its sanitary arrangements.

The Metropolitan Board of Works is elected by the different vestries, and the London Fire Brigade is under its charge. As the water companies are required to provide water without charge in case of fire, those who framed the Acts of Parliament bearing on the subject thought that the public should pay for the cost and maintenance of fire-plugs. So when the Metropolitan Board was constituted under the "Metropolitan Management Act," it was charged with the duty of providing

and maintaining fire hydrants in all those parts of London where constant supply is introduced; and the water companies in any district where they have introduced constant supply, can, therefore, call upon the Metropolitan Board to provide and fix as many hydrants as they (the water companies) think necessary.

The Metropolitan Board of Works is about to be superseded* by the County of London Council, a body to be elected directly by the ratepayers, and not by the members of the vestries as heretofore.

Another respect in which at least our larger cities are decidedly in advance of equally important places here, is the number, comfort and speed of our elevators or "lifts," as they are called here. It seems remarkable, in view of the enormous values of land in London and other large English cities, that the Briton, always mindful of the main chance, has not more eagerly seized upon this means of conveyance, which would at once enable him to double the height of most of his buildings. Having been told of a remarkably advanced and rapid "lift" (of American construction, I believe) in Monument Buildings, near London Bridge, I made a visit to it. I found it fairly lively in its movements, but with a run of only four or five rather low stories, and a car barely accommodating four passengers. So far I have seen nothing on this side comparing for a moment with the four elevators in the Bullitt Building (Philadelphia).

I have noticed, however, one form of lift, which, while it might fail to suit some American requirements, struck me as being at least a novelty, and as having some important compensating advantages.†

Stepping into a large office building on Queen Victoria Street, with the intention of visiting parties in the top story, I was dismayed to find that I had just missed the elevator, which seemed to be moving at a painfully slow rate. I was about to begin a weary pilgrimage up the stairway when to my surprise I noticed a second cage following the one which had just gone up. I then saw that there was an endless series of cages, constantly ascending on the right (as seen from the landing) and descending on the left, and that the passenger had merely to step from the landing into the moving cage to begin his trip, and from the cage to the desired landing (when reached) in order to complete it.

The lifts are manufactured by J. & E. Hall, Limited, of Dartford, Kent, from whom I have obtained the circular sent you, illustrating the arrangement. Each cage is a plain wooden box, about three feet square by seven feet high, and is intended to accommodate two passengers, who must stand, at least in the lift I saw, as the cages there have no seats. Each cage is attached, at its back and near its top, to an endless chain of flat links, which, at the top and bottom of the lift, pass over toothed wheels about four feet in diameter. The weight of the cage, of course, makes its top tend to lean forward from the rear wall of the well in which the cage travels, and to pull the chain with it. This tendency is resisted in the following manner: A vertical guide-bar is fixed to the rear wall of the well and extends from top to bottom of the lift on both the ascending and descending sides. This guide-bar, in cross-section, resembles a box with a narrow opening or slot in its front side, and in it works a T-shaped projection fixed to the back of the cage near its top. The stem of this T passes through the slot in the guide-bar, while the arms of the T, projecting right

* This change has taken place since these notes were compiled.

† I have since found a description of this device in an ancient number of *The Scientific American.*

and left within the hollow guide-bar, are provided with rollers which bear against its front edges. The guide-bar is bent over in a half circle, from right to left, at the top and bottom of the lift, and thus forms a continuous guide for the T-shaped projection from the top of the cage and for the endless chain to which it is attached.

The cage is free to swing laterally about its attachment to the chain, and thus tends to preserve its vertical position while passing from the ascending to the descending side at the top of the lift, or from the descending to the ascending side at the bottom; but to provide against any accidental failure to do so, a horizontal casting is pivoted to the back of the cage near its bottom. The casting reaches across the width of the cage, and its two ends run in vertical guides fixed to the rear wall of the well. One of these guides, of course, is central, or between the ascending and descending paths of the cages, and is closed at its upper and lower ends. The other guide is behind the opposite side of the cage and is continuous, its ascending and descending sides being joined at the top and bottom of the lift by semicircles whose centers are the closed ends of the central guide. When the cage has reached the top or bottom of its run, the inner end of the horizontal casting has reached the closed top or bottom of the central guide, and as the top of the cage passes from one side of the well to the other, the outer end of the casting follows its semicircular guide. The point near the bottom of the cage, where the casting is pivoted, is thus compelled to describe a semicircle having the same radius as that described by the support near the top, and about a center vertically below that of the upper one. As an additional precaution, the link to which the cage is hung, and the casting pivoted near the bottom of the cage, are sometimes provided with toothed wheels over which passes a light, endless chain. The link, in passing over the large wheel at top or bottom, describes a semicircle, and the casting is thus constrained to do likewise.

The lift is operated by a small horizontal steam engine, and travels continuously during business hours. The power required is comparatively small, for the descending cages balance the ascending ones. In the long run, whatever goes up, in the way of passengers, is sure to come down; and a great preponderance of up travel at any one time is scarcely likely, but is provided for by a governor, which increases the power of the engine at such times, and, in combination with a brake, prevents the lift from racing under a preponderance of down travel.

The cages are open on the side facing the landings, and there is no door and no attendant. Of course the speed (about forty-two feet per minute) is very slow as compared with that of American lifts of the ordinary types, for otherwise it would be quite unsafe for ladies, children and elderly persons to step into and from the moving cages; but the loss of time from slow travel is compensated, at least to some extent, by the fact that one never has to wait long for a trip.

The floors of the cages, and those of the landings on the ascending side, are provided with hinges, so as to form flaps about ten inches wide and readily opening upward, thus avoiding danger from projecting toes, etc. There are a dozen or more of these "cyclic" elevators in London.

London Bridge, the farthest down stream on the Thames, with its roadway of only 35 feet wide between curbs, is world-renowned for the enormity of the traffic crossing it, and it is said (but also disputed) that a large and constantly increasing proportion of that traffic, amounting now to more than one-half, comes from points lying below, or to the east of, the bridge, which may well be the case, for below it are all the docks

and large shipping, while the traffic from above it is shared by the other bridges, beginning with Southwark and Blackfriars.

On the other hand, Sir J. W. Bazalgette reported to the Metropolitan Board of Works, in 1877, that an average of twenty-four masted vessels pass daily up the river below London Bridge, and as many down.

While therefore there appears to be urgent need for a relief of London Bridge and for a shorter route across the river for the heavy traffic now crossing from below, the river people will by no means hear of a permanent bridge below London Bridge.

To meet these conflicting requirements, a bridge of remarkable design is now being constructed by the Corporation of London, about half a mile farther down stream, or just below the "Tower of London," built by William the Conqueror, in the eleventh century.

The foundation stone for the present structure was laid by the Prince of Wales, June 21st, 1886.

Mr. J. Wolfe Barry, the engineer, has kindly furnished me the sheet sent you by this mail, giving the only elevation of the bridge that I have seen in print, with the principal dimensions. The central, or channel span, of 200 feet, is closed by two bascule leaves, each consisting of four main girders on a steel shaft 22 inches in diameter resting on eight bearings. The bascules will be counterpoised, and are to be raised and lowered by means of two hydraulic engines of 360 horse power each, located on shore and working two accumulators in each pier. When the leaves are opened to permit the passage of masted vessels, the foot travel will pass over a permanent trussed span, resting upon the massive masonry towers 100 feet above, lifts and stairways being provided in the towers for its accommodation. The trussing of this footway will form the connecting link between the chains supporting the two permanent side spans of 270 feet each.

The river, at the site chosen, is 880 feet wide, with a current running up or down stream, according to the tide, of from three to three and a half miles per hour, and a range of tides of about 20 feet. The piers of the bridge will reduce the high-water cross-section of the river from 24,566 to 20,040 square feet, which is about 740 square feet more than that remaining at London Bridge.

Up to the roadway the piers will be of Gault brickwork in cement, faced with gray granite, and the towers resting upon them will be of brick with stone facings. It is expected that the bridge will be completed in about two and a half years.

Through the courtesy of Mr. John Jackson, contractor for the foundations, I recently had the opportunity of visiting the works now in progress, and was shown over them by his agent, Mr. George H. Scott. The abutments and the northern pier are nearly completed, and the foundations of the southern pier are well under way.

Each of the two piers is 70 feet wide by 185 feet 4 inches long, and about 88 feet deep from the main roadway to the bottom of the foundations.

Around the site of each pier a staging is erected, resting upon piles, and just within this staging are sunk the twelve plate-iron caissons, shown in plan in the sketch herewith. These caissons are open at top and bottom, and their outer edges inclose the site of the pier. They are sunk 15 feet into the London clay by means of divers who excavate around their lower edges, the caissons being also heavily weighted. A space of 2 feet 6 inches is left between each two caissons, but when two adjoining caissons have been driven home, the space between them is cut off from the river by

means of square piles driven between the two caissons at the two ends of the space, as shown, and the two adjoining ends of the two caissons shown by dotted lines are then removed. In this way the twelve caissons are made to form a continuous double coffer-dam, inclosing the site of the pier. The clay of the river bed is then excavated by divers to a depth of 5 feet below the bottom of the caissons and over a space extending 5 feet beyond them on all sides. This space is then filled with concrete, which is also carried up within the caissons to a level with the river bed, or about 27 feet in all. Between the two walls of the coffer-dam the outer shell of masonry of the pier (represented by the shaded portion of the sketch herewith) is built, resting upon the concrete. When this outer shell is completed, the upper or temporary portion of the caissons, 38 feet deep, is detached from the lower portion, 19 feet deep, which remains permanently in the work.

The shell of the masonry, now completed between the inner and outer walls of the coffer-dam, forms in turn the coffer-dam within which the bottom is excavated and filled up with concrete as before, and the inner portion of the pier built up of brick-work, spaces being left in it for the swinging counterpoise ends of the bascule leaves, for accumulators, etc.

Quite a business seems to be done here in lamps burning the vapor of crude mineral oils in a jet of steam or compressed air. At least an active war of advertising goes on between the different makers. The lamps give a brilliant white and roaring flame several inches in diameter and a foot or two in length, and are much used in outdoor building and engineering operations. I send you circulars of the five lamps which seem to be most prominently before the public, viz., Lucigen, Luminator, Jupiter, Wells and Doty. Like most circulars, they are made up chiefly of laudations by the makers and testimonials from users, with very inadequate and unskillfully worded description, but it will be seen that the oil, which is contained in the body of the lamp, is vaporized by heat or by a jet, or both. It is claimed that these lamps are much cheaper than electric lights, while they are much more brilliant than the incandescent, and do not throw such intense shadows as an arc light. The weak point, judging from the zeal with which all plead "not guilty," is the throwing of oil spray over the surroundings.

The "Lucigen" is used at the Tower Bridge Works, and the "Wells" on those for the Manchester Ship Canal. In the "Wells" and the "Doty" each lamp is self-contained, a force-pump (for the oil in the former and for air in the latter) being attached to the lamp itself, while the other lamps named require separate plant for steam or compressed air, a number of lamps being supplied from the same boiler or air compressor.

FEED-WATER HEATER AND PURIFIER.

Regular Meeting, June 1st, 1889.—Mr. W. A. Morse (visitor) presented an illustrated description of the Smith Feed-water Heater and Purifier.

During the past twenty years there has been a remarkable advance in the economy of fuel for steam-making purposes. The general employment of improved types of engines has had much to do with this, and the fuel consumption, instead of being, as in former times, 3½ to 5 lbs. per horse-power per hour, is only about 2 lbs. per horse-power per hour at the present time. But while we must give improved engines due

credit for this great reduction in fuel, there has been even as great an improvement in our steam generators and in means for heating the feed-water, and to them much of this fuel economy is due.

Tubular, tubulous and water-tube boilers of the present day have been evolved from the long, ungainly, unsightly and wasteful cylinder and flue boiler of half a century ago, and our present types of boilers are far superior as steam generators, safer to life and limb, take up far less space, are more economical of fuel, and altogether more satisfactory than the old types. This evolution of the steam boiler has made changes necessary that greatly lessen, and in some types almost entirely preclude the chances of cleaning them in the old way, with hammer and chisel.

Feed-water heaters make it possible to keep boilers clean, no matter of how complicated a type they may be. The Smith Feed-water Heater and Purifier is intended to go inside of a boiler, and is known as a live steam heater or purifier. It consists of a long cylinder, divided by a diaphragm plate running longitudinally its entire length, which is nearly or quite the length of the boiler. It may be made of any shape, and either in one piece or in sections bolted together. To each end is bolted a cap, and in one of these end pieces the diaphragm is absent, allowing the water to pass up around the end of diaphragm in the device into top chamber, and on to the further end before it comes over into the boiler. By this arrangement the feed-water is passed twice the length of boiler before it is allowed to go into the boiler proper, thereby bringing it to the temperature of the water and steam in the boiler. A blow-off cock in the pipe leading from the purifier allows the deposited impurities to be blown out without wasting a large amount of hot water.

MAP PROJECTION AND PERSPECTIVE.

Business Meeting, June 15th, 1889.—The Secretary presented, for Prof L. H. Barnard, by title, a paper, of which the following is an abstract:

Various methods have been devised for projecting the earth's surface, each having some advantage in itself. The polyconic method is here considered, and the shape of the earth assumed to be that of a spheroid, the semi-axes being

$$a = 6{,}378{,}206.4 \text{ meters}, \quad b = 6{,}356{,}583.8 \text{ meters};$$
$$a : b :: 294.98 : 293.98.$$

The U. S. C. & G. Survey Report for 1884 says: "So nearly have these elements been found to represent the curvature and magnitude resulting from the trigonometrical work of the Coast and Geodetic Survey, that no subsequent change in the general dimensions would so far affect the territory of the United States as to make it useful to seek a better general surface of projection for this country."

If a cone be passed tangent to the earth's surface, along a given parallel of latitude, and the cone then developed, the parallel will develop into a circle, with center at the vertex of the cone, and radius equal to the tangent of the pole-distance of the parallel. If, in a similar manner, a cone be passed tangent to each parallel, within the limits of the map, each cone developed, and the developed intersections of each meridian with all the parallels found, and the meridians drawn through these points, the projection so obtained is called polyconic.

The polyconic method, as outlined above, has the following general properties:

(1) The meridians and parallels are perpendicular to each other as in space.

(2) The scale along the central meridian and the parallels is accurate; in other directions nearly so.

(3) The distortion of areas is not excessive. It increases toward the limiting meridians.

(4) It is impossible to have the meridians and parallels at right angles to each other, and preserve the equality of areas. Either must be sacrificed to some extent—usually the latter.

Construction of Maps.

Having determined the limits of latitude and longitude of the area to be projected, and the scale of the map, draw the central meridian, assume the intersection with it of the extreme northern parallel. From this point lay off the actual arc of the meridian to the central and extreme southern parallel; draw through these points, with great accuracy, perpendiculars to the central meridian. Since in any practical case the center of the developed parallel is inaccessible, it becomes necessary to plot the developed intersections of the meridians and parallels by means of co-ordinates. Lay off the co-ordinates x along these perpendiculars, and through these points lay off the co-ordinates y parallel to the central meridian. This will give three points on each meridian, and though their projections are curved lines, in any map not covering more than two hundred square miles, it will be impossible to detect the curvature, hence straight lines through these points will usually determine the meridians. Next divide the distance between the points y on the meridians into a number of equal parts whose value shall be the same as the interval between the meridians. Through the points thus obtained draw curved lines to represent the parallels.

The co-ordinates x and y are given by the equation:

$$x = r \sin C$$
$$y = 2r \sin \tfrac{1}{2} C.$$

To determine the values of r and C: let e be the eccentricity of the ellipse,

$$\text{or } e = \sqrt{\frac{a^2-b^2}{a^2}}$$

$$L = \text{the latitude.}$$

The normal to the minor axis of the ellipse

$$N = \frac{a}{(1-e^2 \sin^2 L)^{\frac{1}{2}}}$$

then
$$r = N \cos L$$

$$C = \frac{1}{N \cot L}$$

The length of 1 min. of meridian

$$= \frac{a(1-e^2)\,(60 \sin 1'')}{(1-e^2 \sin^2 L)^{\frac{3}{2}}}$$

The length of 1 min. of parallel

$$= \frac{a \cos L(60 \sin 1'')}{(1-e^2 \sin^2 L)^{\frac{1}{2}}}$$

In the report of the U. S. C. & G. Survey for 1884, Appendix No. 6, extended tables are given covering every case from 0° to 90° latitude.

Perspective.

If the point of sight be at some finite distance from an object, the projection is called scenographic, and gives a perspective of it. That is, it represents an object as it appears to be, not as it really is.

Definitions.—A visual ray is a right line drawn through the point of sight.

A plane of rays is one passed through the point of sight.

The plane upon which the perspective is made is called the plane of the picture.

The intersection of the horizontal plane of rays with the plane of the picture is called the horizon.

Having determined the relative positions of the point of sight, plane of picture and object, the perspective of any point of the object is where the visual ray through the point pierces the plane of the picture.

If a plane of rays be passed through any right line, its intersection with the plane of the picture is the perspective of the line.

It follows from this definition that the perspective of a vertical line is parallel to the line itself; also, that the point where any line of the object pierces the plane of the picture is a point in the perspective of the line.

If a visual ray be drawn parallel to a right line or system of parallel right lines of an object, the point where it pierces the plane of the picture is called the vanishing point of the line, or of the system of parallel lines. If the line or system be horizontal, as is usual in any practical problem, the vanishing point is in the horizon.

The vanishing point of a right line or a system of parallel right lines is evidently the perspective of the infinitely distant point in which the line or each line of the system intersects the parallel visual ray. Hence the vanishing point of a line or system of parallel lines is a point in the perspective of each of them.

The perspective of any line may then be found by joining the point where it pierces the plane of the picture with its vanishing point.

The perspective of curved lines may usually be found by drawing auxiliary lines, such as tangents and diameters, and finding the perspectives of them and sketching in the perspective of the curve.

If it be a circle, its prespective will in general be an ellipse whose axes can be readily determined and points on its circumference constructed.

It is believed that the above statements in *italics* can be made to cover every construction in perspective that may arise in the practice of mechanical draughting.

PILE DRIVING BY JETS.

Business Meeting, November 2d, 1889.—The Secretary presented, for Mr. Edward Hurst Brown, a description of the application of a water-jet to the driving of piles for the board-walk at Atlantic City, N. J.

The water was brought from the city water supply in a 2-inch pipe, extending along the line of the work. To the end of this pipe (which was extended as the work progressed) was attached a 30-foot length of rubber fire hose terminating in an ordinary brass nozzle about 4 feet long, with an opening of $1\frac{1}{4}$ inches.

The piles were swung into position by a rough but light tripod, provided with block-and-fall, and steadied in place by the foreman, while one of the men held

the nozzle of the hose vertically and close to the foot of the pile. Under the action of the jet, the pile was lowered into position almost as fast as the men could pay out the rope, the nozzle following it down.

To drive a pile from 6 to 10 feet into the compact beach sand required only from 30 seconds to 1 minute from the time the water was turned on the foot of the pile, until the pile was finally fixed in position, the hose withdrawn and the tripod removed.

The instant the hose was withdrawn, the sand packed at once around the pile, holding it, apparently at least, as firmly as if driven by a ram in the usual way. Should a pile be driven too far, it is easily raised while the jet is on.

The jet process has been successfully used in other parts of New Jersey, in some places through coarse gravel with stones 8 to 10 inches in diameter, but in such cases, of course, the sinking is less rapid than in the beach sand.

When a city water supply is not at hand, a steam force-pump is used.

In sinking pipe-wells the pipe itself may be used for the jet, but the separate nozzle appears to be preferable.

RIGHT OF WAY.

Regular Meeting, December 21st, 1889.—The Secretary presented, for Mr. G. W. Chance, a paper, of which the following is an abstract:

Right of way is obtained originally by location surveys followed by the necessary legal papers, and, when this has to be corrected, re-surveys must be made and all the old papers relating to the subject examined. After the location surveys are made, the proper method of securing the right of way, if maps have not yet been prepared, is to contract for deeds, not specifying any definite width, at a certain price per acre, binding the contract by paying a nominal sum. For a single-track road in rolling farming country a 100-foot right of way is ample. After the final location is made, deeds should be drawn up for right-of-way maps describing the land taken by metes and bounds and containing a covering clause, such as "being a strip of land eighty (80) feet wide, forty (40) feet on each side of the center line of the —— Railroad, as the same shall be finally located," etc.

In making a re-survey a system of stationing should be established. Stakes should be driven five feet from the rail and four hundred feet apart, measurements to be made by a 200-foot steel tape, each hundred feet being marked on the inside of the rail for the transit men following.

The transit party should make a complete re-survey of the line, sending copy of their field notes immediately to the office for plotting. Levels should be checked wherever possible by obtaining elevations for intersecting lines.

All measures should be taken from the center line as it exists on the ground, fixing carefully the position of all objects on the right of way, such as signal posts, switches, bridges, etc.

Plotting should be on sheets 37 inches by 15 inches, with a 1½-inch border, three draughtsmen being required. Lettering should be uniform and tinting used sparingly. The scale of the maps should be the same, two hundred feet to the inch being convenient, with sub-sheets to a scale of fifty feet to the inch. Maps may be bound in counties, or according to stations, with a graphical index on a scale of 2,000 feet to the inch for each volume.

An abstract of all the original instruments in the company's possession pertaining

to each tract, should be carried on each map, with a reference to the location of the papers in the company's archives, and the papers as abstracted should be stamped, " Entered on sheet —— county." Imperfect titles should be noted on the maps, to be checked off as perfected by the legal department.

RIVETED JOINTS.

Regular Meeting, December 21st, 1889.—Mr. James Christie presented a paper referring to a series of experiments with both punched and drilled holes, undertaken in order to ascertain the correctness of the proportion usually adopted between the diameter of the rivet and the net section of metal between rivets, in the single-riveted lap-joints commonly used in the circular seams of steam boilers.

Inasmuch as the strength of such a joint, as proportioned in the average best practice of the day, is only about half that of the solid plate, it will be readily seen that a small variation in these respects may seriously affect the efficiency of the joint.

Taking an average of the standard practices of several leading manufacturers in this vicinity, we find the net plate section remains 63 per cent. of the solid plate, and 7 per cent. less than the rivet section, while the bearing surface of the rivets is 8 per cent. less than the net plate area.

In the experiments referred to, the details of which are not given, the diameter of the rivet, starting from this current practice as a basis, was gradually enlarged, or the pitch reduced, with the result that the strength of the joint was thereby increased until a maximum was reached of an efficiency of from 65 to 70 per cent. At this point the rivet area had a ratio to the reduced plate section of about two to one for iron rivets in iron plates, while for iron rivets in steel plates of 60,000 lbs. tensile strength the ratio of rivet to net plate section was about two and a half to one.

In all cases the binding of the joint, due to enlarging the rivet area, was found to increase the strength of the joint.

The rivets were driven by a compression varying from twenty to thirty tons.

An analysis of the experiments showed that this increase of efficiency was due to the clamping force exercised by the rivet-heads, with possibly a slight gain due to better bearing surface.

The opinion has been generally held that this clamping force, exerted by the rivet heads, is too uncertain a quantity, both as to its amount and as to its persistence, to be of positive value as a factor of constant resistance in a riveted joint; and in ordinary construction, where several plates are joined, where the holes may be imperfectly filled, and where close contact between the plates is questionable, the permanence of this force may be doubtful, nor is it necessary to rely upon it; but in a steam boiler the case is otherwise, for there a relaxing of this force would result in a leaky seam, which would at once betray the fact and compel a closing-up of the loose rivet.

THE ÆSTHETIC VALUE OF ENGINEERING CONSTRUCTION.

Regular Meeting, December 21st, 1889.—Mr. Edward Hurst Brown presented a paper upon the Æsthetic Value of Engineering Construction.

In his plea for the consideration of beauty of design, the author deplores the util-

itarianism of the present age and of the Anglo-Saxon race in general, with its neglect of the beautiful, our cultivation of which has not kept pace with our advances in science and in material comfort. Beautiful landscapes are disfigured by furnace stacks, railroad embankments, iron bridges and other unsightly structures, to say nothing of still more harrowing advertisements. The stone aqueducts and arched bridges of the ancient Romans are cited in order to show that such defacement is unnecessary, and that, indeed, a more lasting construction is compatible with great beauty of form.

"The Eiffel tower is a thoroughly practical piece of engineering, yet with the unerring artistic instinct of the Latinized Celt its designer has shaped its sides in graceful curves, which form a satisfactory design in themselves. An American engineer would have built as strong a tower, and perhaps a higher one, but who can doubt that it would have been an ugly one?"

A structure out of harmony with its natural surroundings is an æsthetic untruth and even worse than a spoken lie, for the latter dies of itself, while the former remains to vex the eye and deprave the taste of future generations.

NOTES ON ENGINEERING DRAWING.

Regular Meeting, April 5th, 1890.—The Secretary presented, for Mr. Frank Cooper, notes of which the following is an abstract:

Drawings should be absolutely plain, clear and distinct, and of such character that they can be finished rapidly. Fancy draughting is out of place and generally deficient in clearness.

Original drawings should be made on Whatman's smooth-surfaced sheets, as they can be rolled and kept so for a long time without cracking or rotting. For ordinary work imperial vellum tracing cloth is excellent. Liquid indelible ink and moist water colors are required. When blue prints are required the blue and brown colors should be mixed with white to produce satisfactory lines. Tinting should be done on the glazed side, the drawing having been made on the unglazed side. If the glaze refuses to take the work, drying will assist in producing the desired effect. The moist colors may be used for tinting, except where lines or figures appear on the opposite side, when it is desirable to use the transparent indelible colors.

The general lettering should be in plain print, while Roman capitals can be used for headings and titles on larger maps.

Plotting from slope angles can be most conveniently done by using a table showing the distance apart of the contours, for given slope angles and difference of elevation of contours required; or it is more convenient to make a series of cardboard scales to the scale of the drawing, for slopes up to 25°, say 15′, 30′, 1°, 2°, 3°, 4°, 6°, 8°, 10°, 13°, 16°, 20°, 25°.

Topographical maps should be tinted lightly in transparent inks, and the contours drawn in fine black lines. When prints are not required, burnt sienna contour lines improve the general appearance of the map.

The most convenient scales to use are 1 inch = 100 feet and 1 inch = 50 feet. The rubber curves are usually cut to the first of these scales. Much unnecessary labor will be saved by adopting two or, at most, three scales for all drawings. Rubber curves, graduated to 30′, 1°, 1°15′, 1°30′, 1°45′, etc., will be found more convenient than those graduated to even radii in feet.

Drawings are filed either by rolling, tagging and pigeon-holing, or by laying flat in drawers. The latter is by far the best way. Drawers should be 4″ deep and divided into compartments from $2\frac{1}{2}'$x$4'$ to 12″ square. Tag the drawings on the back with neat gummed tags, in say the lower right-hand corner, and keep the face downward with the highest number on top. Provide a book, in which all drawings are filed alphabetically, under all the headings where they are likely to be looked for. Drawings can then be readily found, and it can be instantly determined whether they are in or out of the office.

ABSTRACT OF MINUTES OF MEETINGS.

Of the Club.

(Continued from Vol. VII., No. 6, page 387.)

May 3d, 1890.—Business Meeting.—President H. W. Spangler in the chair; 23 members and one visitor present.

Messrs. A. H. Haig and Barton H. Coffey, the Tellers of Election, reported that only 124 votes had been cast for and against the amendment to increase the dues of Resident Active Members and Associate Members, by $2.50 per annum, for the purpose of creating a fund to provide a lunch after each of our meetings. Seventy-six of these votes were in favor of the amendment and forty-eight against it. It therefore lacked the necessary two-thirds majority, but in view of the smallness of the vote, it was thought there might have been some misapprehension on the subject, so the amendment was again submitted by Messrs. Howard Murphy, Edward Hurst Brown and M. R. Mucklé, Jr.

The Secretary presented, for Mr. William H. Dechant, a paper on the Mountain Railroads of Reading, Pa.

The paper was accompanied by a topographical map which had been made by Mr. E. V. d'Invilliers. On this map the alignments of the road have been placed, at the instance of Mr. d'Invilliers, thus giving an excellent idea of their character and surroundings. The scenery, from numerous stretches of these railroads, is grand and beautiful. Their accessibility from Philadelphia and other cities is a great advantage.

The Secretary presented, for Mr. J. Foster Crowell, a paper on the Inter-oceanic Canal Prospect in 1890, from Notes on the Spot in Panama and Nicaragua. He describes the extravagant ruins of machinery and executed work which prevail along the Panama Canal, and expresses his opinion that its completion is utterly hopeless. On the other hand, he expresses every confidence in the economical and satisfactory completion of the Nicaragua route.

Mr. Edwin S. Crawley presented a paper, translated from the French—Nouvelles Annales de la Construction—on the Lobnitz

System for the Demolition of Rocks under Water without Explosives. In this system the rock is shattered by the action of a heavy mass let fall from a convenient height and acting like a projectile upon the wall of a fortress.

Owing to the lateness of the hour, the other papers set down for the evening were deferred.

May 17th, 1890.—Regular Meeting.—President H. W. Spangler in the chair; 35 members and two visitors present.

Prof. J. W. Redway read a paper on the Physical Geography of the Mississippi River.

The Secretary presented, for Mr. George W. Creighton, a paper on Rail Joints.

The Club then adjourned to the lower rooms to partake of the excellent lunch which had been provided under the direction of a committee consisting of Messrs. Edward Hurst Brown, chairman, M. R. Mucklé, Jr., and Henry G. Morris.

There seemed to be no doubt in the mind of any member present that the relaxation and social intercourse promoted by a lunch of this kind would form a most agreeable addition to the *régime* of the Club.

June 7th, 1890.—Regular Meeting.—Vice-President Wilfred Lewis in the chair; 15 members were present and one visitor, Mr. Wm. P. Shinn, President of the American Society of Civil Engineers.

On motion of Mr. Henry G. Morris, the sense of the meeting was unanimously expressed in favor of officially indorsing the invitation, which had been extended to the Local Committee on Reception of the British Iron and Steel Association, to make such use of our House as they might find convenient.

The Secretary presented, for Mr. Strickland L. Kneass, a description of a new Condensing and Refrigerating System.

The Secretary announced that there would be a lunch served after the next meeting on June 21st, 1890.

June 21st, 1890.—Business Meeting.—Vice-President Wilfred Lewis in the chair; 30 members and one visitor present.

The minutes of Business Meeting, May 3d, 1890, were approved.

The Tellers of Election, Messrs. Codman and Coffey, reported that 143 votes had been cast, and that the following were elected: *Active Members*, Messrs. E. Jones Acker, George T. Barnsley, C. J. Bechdolt, Thomas Reath Brown, George A. Bullock, Easton Devonshire, A. L. Eltonhead, Frank G. Fahnestock, W. L. Ferguson, Herbert M. Fuller, David Leavitt Hough, George R. Ide, Jerome T. Kelly, R. H. Lee, Jr., Alan N. Lukens, H. S. Meily, Teile Henry Müller, Elias W. Oviatt, S. B. Peck, James Reed, S. R. Stubbs, T. Kennard Thomson and William Vollmer; *Associate Members*, Charles G. Hildreth and Robert J. Parvin.

The Tellers also reported that 140 votes had been cast upon the amendment to the By-Laws, increasing the dues of Resident Active Members and Associate Members to $10 per annum; that 98 votes had been cast for the amendment and 42 against it. 94 votes being the two-thirds majority required to pass the amendment, the amendment was declared adopted.

The Secretary presented a letter from Mr. E. L. Corthell, Active Member of the Club, inclosing a copy of an address made by him before the Western Society of Engineers, in regard to participating in erecting a monument to the late James B. Eads; the said monument to be erected in St. Louis at an estimated cost of from $15,000 to $18,000. The letter concludes with the request that all those who desire to join the Monument Association should send their names through the Secretary to Col. E. D. Meier, C.E., Bank of Commerce Building, St. Louis, Mo.

The Secretary presented, for Mr. Robert A. Cummings, an illustrated paper on Granolithic Pavements, in which Mr. Cummings describes this form of pavement, giving European practice with regard thereto, etc., together with a table of tests of cement and granite dust.

There was some discussion of this paper by Mr. Edward Hurst Brown.

October 4th, 1890.—Business Meeting.—President H. W. Spangler in the chair; 31 members and one visitor present.

The Secretary presented a correspondence with regard to the

participation by the Club in the proposed International Congress of Engineers to be held during the coming World's Fair at Chicago, and moved that a committee of three, to consist of the President and two other members to be named by him, should be appointed to take up this subject so far as this Club is concerned. It was so ordered.

The meeting then adjourned.

The lower rooms of the Club House were occupied by members of the British Iron and Steel Institute, the Verein Deutscher Eisenhüttenleute and the American Institute of Mining Engineers, who, by invitation, were making their headquarters at our Club House during their visit to Philadelphia.

October 18th, 1890.—Regular Meeting.—President H. W. Spangler in the chair; 21 members and one visitor present.

The minutes of the last Regular Meeting, June 7th, 1890, were approved.

At the last meeting, which was a Business Meeting, it was ordered that a committee be appointed, to consist of the President of the Club and two members whom he might select, to consider the question of participation by our Club in the proposed International Congress of Engineers at the time of the coming World's Fair in Chicago.

The President presented, at the hands of the Secretary, a report stating that he had appointed Messrs. Wilfred Lewis and E. V. d'Invilliers as the other members of this Committee, and setting forth what had been done by the Committee.

The present not being a Business Meeting, this report was presented merely in order to get some idea of the sense of the Club with regard thereto.

On motion of the Secretary, the sense of the meeting was expressed to the effect that it is desirable for the Board to consider the said report in full, and report to the Club at the next Business Meeting.

The Secretary presented, for Mr. Robert A. Cummings, a photograph and description illustrating the effect of gases from locomotive stacks upon vegetation.

Mr. Arthur Falkenau presented an extensively illustrated de-

scription of a new Method of Making Barrels by Machinery. The drawings illustrating this description are of so elaborate a character that it would be impossible to give a comprehensive abstract.

There was considerable discussion of this subject, principally by Messrs. Henry G. Morris, Wilfred Lewis, John C. Trautwine, Jr., Max Livingston and the author.

NOVEMBER 1ST, 1889.—Business Meeting.—President H. W. Spangler in the chair; 21 members present.

The minutes of Business Meetings June 21st, 1890, and October 4th, 1890, were approved.

The Secretary presented a report from the Committee which had been appointed to represent the Club at the Convention of representatives of the Engineering Societies, held in Chicago, with reference to the part the Engineers of this country should take in the coming World's Fair in Chicago. This Committee consists of President H. W. Spangler, chairman, and Messrs. Wilfred Lewis and E. V. d'Invilliers.

The report of this Committee is given in full on the following circular, which was issued to our members:

Philadelphia, October 18*th*, 1890.

TO THE ENGINEERS' CLUB OF PHILADELPHIA.

GENTLEMEN:—The President, in pursuance of a resolution passed at the last meeting of the Club, appointed a committee, consisting of the President as chairman, Mr. Wilfred Lewis and Mr. E. V. d'Invilliers, to respond to the invitation of the Western Society of Engineers of Chicago to take part in the preliminary discussion on the subject of the part the Engineers of this country should take in the World's Fair of 1893.

At the meeting held on the 14th inst., all the members of your Committee were present, the Chairman remaining to the adjourned meeting held on the 15th.

Representatives from the following-named societies took part in the proceedings, viz.:

American Society of Civil Engineers.
American Society of Mechanical Engineers.
American Institute of Mining Engineers.
Canadian Institute of Civil Engineers.
American Institute of Electrical Engineers.

Civil Engineers' Club of St. Paul.
Engineers' Club of Philadelphia.
Engineering Association of the Southwest.
Engineers' Club of Cleveland.
Engineering Society of Western Pennsylvania.
Engineers' Club of Minneapolis.
Wisconsin Electric Club.
Civil Engineers' Club of St. Louis.
Chicago Western Society of Engineers.

A plan was presented by Mr. E. L. Corthell, a delegate from the Western Society of Engineers (who is also a member of this Club), which, after considerable informal discussion, was referred to a committee of five to report at 9.30 Wednesday.

The following is a report of this committee :

Chicago, Ill., October 15th, 1890.

To the Chairman of the Convention of Delegates from Engineering Societies of the United States and Canada.

Dear Sir :—Your Committee on plan for establishing and maintaining a joint Engineering Headquarters in Chicago in 1893, during the World's Columbian Exposition, and for holding an International Engineering Congress at some time during the Exposition, beg leave to report.

It finds itself unable to present at this time more than a brief outline plan.

The proposition advanced by the Committee of the Western Society of Engineers to this convention yesterday embodies our views, with some changes which we have made in the plan herewith submitted :

First.—Engineering Headquarters.

In view of the existence in this country of several large Engineering Societies of high rank, which will desire the use of headquarters for their own members and for the entertainment of foreign visitors, and the inconvenience and expense which would result from the maintenance of separate establishments, we think it is very desirable that all the Engineering Societies of recognized standing in the United States and Canada be requested to unite in establishing and maintaining a joint Engineering Headquarters during the continuance of the Exposition.

The Exposition management will probably furnish space free of charge within the Exposition buildings, but it may be deemed advisable to provide additional quarters outside ; the headquar-

ters to be a rendezvous for all the members of the Engineering Societies in this country, and their use to be tendered to all foreign Engineers.

It is expected that the staff shall consist of a joint secretary and two or more assistants, some of whom shall speak the principal European languages. The staff to be charged more especially with:

(*a*) To give information concerning the location of various Engineering exhibits within the Exposition.

(*b*) To give visiting and foreign Engineers information about points of engineering interest outside of the Exposition, and to aid their investigations in other ways.

(*c*) To give visiting and foreign Engineers introductions to those whom they desire to meet, and to promote social intercourse.

(*d*) To keep a record of the address of visitors, and to invite them to the International Engineering Congress hereinafter outlined.

It is estimated that the expense will amount to about $10,000. This, it is suggested, may be met by an assessment of one dollar per member on each Engineering Society of this country which shall join this proposed association, and also by voluntary contributions. The details to be hereafter adjusted.

It is evident that this plan will be far more economical than that of maintaining separate headquarters by the several societies

Second.—Engineering Congress.

At some time, to be hereafter designated, during the Columbian Exposition, it is proposed to hold within the Exposition, in a building which the management thereof proposes to furnish, an International Engineering Congress, open to Engineers of all nations. This Congress to last six days, and to be conducted in the English language.

The opening session of welcome and organization to be a joint session, and if warranted by the attendance and the number of papers offered, the Congress then to be divided into sections to consider and discuss the various branches of Civil, Mechanical, Mining, Metallurgical, Electrical, Military and Naval Engineering.

A chairman and secretary for each section to be designated in advance, and the sessions to be so timed that papers and discussions on allied subjects shall not occur simultaneously, so as to preclude those interested from attending several sections.

The Congress to terminate with another joint session.

All papers, so far as practicable, to be furnished in advance, to

be carefully examined by the proper committees under rules to be hereafter laid down, and, if found acceptable, to be printed for distribution in advance to the members of the Congress, at which they are to be chiefly read by title so as to admit of immediate discussion.

Intending contributors to be requested to confine their papers, so far as possible, to such new and recent constructions, machines, processes, methods, experiments and investigations, including proposed standards of tests and measurements, as are of engineering importance. Papers on purely speculative subjects should not be received.

A small fee (say $2.00) to be paid by members attending the Congress to defray its expenses. The papers and discussions to be subsequently printed and furnished to such members as may so request, at a stipulated price.

A General Permanent Committee, to be chosen in advance, to organize the above proposed headquarters and Congress.

Respectfully submitted,

(Signed by the entire Committee.)

It was *resolved*, that the report of the Committee on International Congress and Joint Headquarters be accepted and that we report the same to our respective societies, with the recommendation that action in approval or disapproval of the same be taken within the next two months, and that we desire the present committee to be continued with power to carry on the correspondence and organization until its successor is appointed.

It was also *resolved*, that it is the sense of this convention that the General Permanent Committee on the International Congress and Engineering Headquarters be composed of one member from each of the societies which shall join in the plan, except that the American Society of Civil Engineers, the American Society of Mechanical Engineers, the American Institute of Mining Engineers, the American Institute of Electrical Engineers, and the Canadian Society of Civil Engineers may each appoint two members, and the Western Society of Engineers of Chicago may appoint three members of such Committee.

The Committee of the Convention was also empowered to call the General Permanent Committee together at some convenient time after January 1st, 1891.

The convention then adjourned *sine die*.

Your committee recommend that the matter be referred to the Board of Directors with direction to report at the next meeting of the Club as to the advisability of the Club's taking part in the

proposed Engineering Headquarters and International Congress as outlined or with such modification as may be necessary.

Respectfully submitted,

H. W. SPANGLER, *Chairman of Committee.*
WILFRED LEWIS,
E. V. D'INVILLIERS.

This report was presented to the Board of Directors at their special meeting on October 25th, 1890. The following is an abstract from the minutes of the Board meeting, and this abstract was also presented by the Secretary:

"The President, at the hands of the Secretary, presented the report of the Committee appointed to represent the Club in the matter of the Engineers' Headquarters, which it is proposed to establish, and the Engineers' Congress which it is proposed to hold, in Chicago during the coming World's Fair. The Committee representing the Club consists of the President, H. W. Spangler, and Messrs. Wilfred Lewis and E. V. d'Invilliers. After some discussion, on motion of Mr. George Burnham, Jr., seconded by Mr. Henry G. Morris, it was ordered that the Board transmit this report to the Business Meeting of the Club, to be held on November 1st, with favorable recommendation, but with the understanding that the Board recommend that any funds required shall not be taken from the Club treasury, but that circulars be sent to members of the Club, which circular shall include the said report, and ask for contributions of $1.00 from each member of the Club, and special contributions from those members who desire to contribute an extra amount, so that the Club may make a good showing."

On motion of Mr. C. E. Billin, seconded by the Secretary, it was ordered that the Secretary be instructed to send a notice to the members of the Club, to the effect that the recommendation of the Board was adopted by the Club, with the understanding that the contribution of the Club should be limited to $500, and that members be invited to each send a contribution of not less than $1.00 to this fund.

Mr. Benjamin Franklin presented a paper upon the Application of Drain Tiling to the improvement of Ground for Residences.

There was some discussion of this paper. Mr. Howard Murphy noted a case where drain tiling had been used by him around a private residence in order to relieve the flooding and dampness in the cellar.

The Secretary presented, for Mr. Harvey Linton, a paper upon Topographical Surveying, with photographic illustrations.

The Secretary presented the resignations from Active Membership of Messrs. Wm. H. Burr, Wm. O. Dunbar and Edward I. H. Howell.

November 15th, 1890.—Regular Meeting.—President H. W. Spangler in the chair; 31 members and 7 visitors present.

The minutes of Regular Meeting, October 18th, 1890, were approved.

The Secretary presented an application of a Mechanical Engineer of 12 years' experience for a position.

Mr. Robert J. Parvin, at the hands of the Secretary, presented a handsome pointer to the Club, to be used in explaining the large illustrations often presented at the meetings. It was received with a vote of thanks.

The Secretary called attention to the question of contributions to the Club subscription to the proposed Engineering Headquarters and Congress at the World's Fair in Chicago.

The Secretary presented, for Mr. R. Taylor Gleaves, a description of Continuous Rails for Railways.

December 6th, 1890.—Business Meeting.—President H. W. Spangler in the chair; 35 members and 3 visitors present.

The minutes of Business Meeting, November 1st, 1890, were approved.

Officers were nominated to serve during the fiscal year 1891.

The Secretary presented a letter from Mr. E. L. Corthell, Active Member of the Club, expressing the gratification of the Chicago Engineers at the action taken by our Club with regard to the proposed Engineering Headquarters and Engineering Congress during the coming World's Fair at Chicago.

The Secretary presented an application for a draughtsman.

The Secretary presented a letter from Captain S. C. McCorkle, accompanying the latest chart issued by the Coast Survey of the

Territory of Alaska, mentioning it in connection with a proposed railway uniting Alaska and Russia by way of Behring Straits.

The Secretary presented, for Mr. C. E. Billin, a letter including the following resolution :—" That a Committee of three members be appointed by the President to consider the best means of increasing the interest in the Club and in its meetings.

" That said Committee shall inquire into the advisability and expense of printing any or all papers presented to the Club, and distributing printed copies to all members and the press, previous to the meeting at which they are to be discussed.

" That said Committee shall report at the next meeting of the Club, and shall submit such motions as may be necessary to carry out and make effective such changes as it may consider desirable and for the Club's welfare."

This resolution was seconded by Mr. F. H. Lewis, and after some discussion was passed.

Mr. John E. Codman presented notes on the Rain-fall in the vicinity of Philadelphia, in 1889. He referred to the extraordinary storms which had prevailed during that year, and gave a detailed and interesting description of the automatic rain gauge which has been used by the Philadelphia Water Department, in order to determine the rain-fall with accuracy.

Mr. Strickland L. Kneass presented a paper on the Internal Condition of an Elastic Fluid during Discharge through an Orifice.

There was some discussion by Prof. H. W. Spangler, Mr. Wilfred Lewis, Mr. J. C. Trautwine, Jr., Dr. H. M. Chance and Mr. Howard Murphy.

Mr. Wilfred Lewis presented a description of a new Feed Rachet, invented by him, which he illustrated by a specimen of the same.

There was some discussion by Mr. M. R. Mucklé, Jr.

December 20th, 1890.—Regular Meeting.—President H. W. Spangler in the chair; 21 members present.

The minutes of Regular Meeting, November 15th, 1890, were approved.

Mr. Edward Hurst Brown presented a paper on Suburban De-

velopment, in which he referred particularly to the development of suburban places of residence in the vicinity of Philadelphia.

There was considerable discussion by Messrs. Henry G. Morris, Robert J. Parvin, A. G. Rudderow and C. H. Ott.

Mr. Henry G. Morris advanced the opinion that a large building, something after the order of the Drexel Building in Philadelphia, could be most advantageously used as a place of residence by families; that a city could be constructed with such places on alternate squares, arranged after the manner of the black squares on a checker-board, leaving the other spaces open for healthful breathing spaces and various purposes.

The Secretary presented, for Mr. John Graham, Jr., a paper upon the Use of a Pumping Dredge by the Norfolk Company at Norfolk, Virginia.

There was some discussion by Mr. Robert J. Parvin, in which he referred to dredging work in California.

The Secretary presented, for Mr. G. R. Henderson, a paper on Crown Bar Stays, illustrated by two drawings of stays, and giving the formulas by which they were proportioned in his practice, also the results of actual tests as to strength.

There was some discussion.

The Secretary presented, for Mr. Charles H. Haswell, a brief paper upon Shingle for Concrete and Beton. He is of the opinion that shingle, under certain conditions, is superior to broken stone in the composition of concrete and beton, both in strength and in economy of cost.

There was some discussion by Dr. H. M. Chance and Mr. Howard Murphy.

Of the Board of Directors.

(Continued from Vol. VII, No. 6, Page 392.)

May 17th, 1890.—President H. W. Spangler in the chair. Present, Messrs. Lewis and d'Invilliers, and Mr. H. C. Woodward, who had been arranging the pamphlets in the library.

The minutes of Regular Meeting April 19th, 1890, were read and approved.

A communication with regard to associating an advertising agent with the Club in the matter of advertisements in the Proceed-

ings, was presented by the Secretary and referred to the Publication Committee.

Mr. Woodward explained to the Board what he had done and what he recommended with regard to the pamphlets in the library. He considered that about $130 would pay for his services to the completion of the work now contemplated. This expenditure was authorized.

June 21st, 1890.—Vice-President Wilfred Lewis in the chair. Present, Messrs. Burnham and Morris.

The minutes of Regular Meeting, May 17th, 1890, were read and approved.

Twenty-five dollars were appropriated for the purpose of paying for the lunch to be served after the meeting this evening.

The matter of obtaining advertisements for the Proceedings was referred to the Publication Committee with power to act.

The Secretary and Treasurer reported that his accounts for the fiscal year 1889 had been audited by the Finance Committee.

The Secretary presented a letter from Mr. E. L. Corthell with reference to participation by members of the Club in the erection of a monument to the late James B. Eads. This matter was referred to the Business Meeting of the Club, the Secretary to notify members with regard thereto.

October 25th, 1890.—President H. W. Spangler in the chair. Present, Messrs. Lewis, Burnham and Morris.

The minutes of Regular Meeting, June 21st, 1890, were read and approved.

The Secretary presented circulars and printed invitations which had been received from the Denver Society of Civil Engineers and Architects to their first Convention at Manitou. The Secretary was directed to acknowledge the receipt of these documents with thanks.

The President, at the hands of the Secretary, presented the report of the Committee appointed to represent the Club in the matter of the Engineers' Headquarters which it is proposed to establish, and the Engineers' Congress which it is proposed to hold in Chicago, during the coming World's Fair. The Com-

mittee representing the Club consists of the President, H. W. Spangler, and Messrs. Wilfred Lewis and E. V. d'Invilliers. After some discussion, on motion of Mr. George Burnham, Jr., seconded by Mr. Henry G. Morris, it was ordered that the Board transmit this report to the Business Meeting of the Club, to be held on November 1st, with favorable recommendation, but with the understanding that the Board recommend that any funds required shall not be taken from the Club treasury, but that circulars be sent to members of the Club, which circulars shall include the said report, and asked for contributions of $1.00 from each member of the Club, and special contributions from those members who desire to contribute an extra amount, so that the Club may make a good showing.

The Secretary stated that Mr. John C. Trautwine, Jr., was considering the matter of having special reprints made and published of the translation which was made by him and Mr. Marichal of Bazin on Weirs, the said reprints to be regularly published for sale. The Secretary desired to learn the opinion of the Board in this matter, as no case just like it had heretofore occurred.

It was ordered by the Board that permission be given to Mr. Trautwine to so reprint this article, provided it was clearly stated in the reprint that it was reprinted from the copyrighted Proceedings of the Engineers' Club of Philadelphia, by permission of the Board of Directors, and that the party publishing the book should pay for the plates at the cost of the same to the Club, but allow the Club to have the use of them whenever so requested.

November 15th, 1890.—President H. W. Spangler in the chair Present, Mr. Henry G. Morris.

The minutes of Special Meeting, October 25th, 1890, were read and approved.

Mr. Henry G. Morris presented the check of Mr. J. Tatnall Lea for $100, being a contribution to the Club from the Local Committee on the Entertainment of the British Iron and Steel Institute, the Verein Deutscher Eisenhüttenleute and the members of the American Institute of Mining Engineers.

The Secretary was directed to acknowledge the receipt of this contribution with thanks, and to place the same in the treasury of the Club.

DECEMBER 20TH, 1890.—President H. W. Spangler in the chair. Present, Messrs. Wilfred Lewis and Henry G. Morris.

The minutes of Business Meeting, November 15th, 1890, were read and approved.

There was an informal discussion as to the condition of the finances of the Club. The Secretary and Treasurer furnished general figures for the information of the Board.

The Secretary suggested that Professor H. W. Spangler, President of the Club, be invited to sit for his phototype portrait for insertion in our Proceedings, etc. On motion of Mr. Henry G. Morris, it was unanimously so ordered.

CONTRIBUTIONS TO THE LIBRARY.

From January 1st, 1890, to January 21st, 1891.

From THE INSTITUTION OF CIVIL ENGINEERS, London.

Haupt—Jetties.
Polonceau—Compound Locomotives.
Hopkinson—Hydraulic Packing Presses.
Kennedy—The Tacheometer.
Dowdall—Scientific Fortifications in China.
Bolton—Inland Steam Navigation in Northeast India, from 1832.
Barron—Piers and Harbors on the North and West Coasts of Scotland.
Reynolds—Triple Expansion Engines and Engine Trials.
Thornycroft—Water-Tube Steam Boilers for Marine Engines.
Lyster—Recent Dock Extensions at Liverpool.
Wheeler—Bars at the Mouths of Tidal Estuaries.
Barry—Deep-water Quays in the Port of Cork.
Donkin—Method of Taking the Temperature of the Cylinder Walls of a Steam Engine.
Hart, Orange and Turner—Water Works in China and Japan.
Milne—Building in Earthquake Countries.
Wordingham—Telephonic Switching.
Sheppard—Reclamation of Lake Aboukir.
Robinson—Barry Dock Works.
Price—Lough Erne Drainage.
Airy—The Action of Quicksands.
Abstracts of Papers in Foreign Transactions and Periodicals—Vols. XCIX, C, CI, CII.
Ker—Concrete Quarters for Native Clerks, Guards, and Menial Staff of Indian Railways, etc.
Burge, Walton and Cruttwell—Railway Bridges.
Airy—Probable Errors of Surveying by Vertical Angles.
Barnaby—Screw Propeller.
Biggart—Wire Ropes.
Bramwell—Welding by Electricity.
Faweus and Cowan—Keswick Water-Power Electric Light Station.
Gill—Artesian Wells in South Lincolnshire.
Meik—Coasts and Rivers of Yesso.
Swainson—Calliope Graving-Dock, Auckland, N. Z.
Addison—Barytes and Umber Mines and Refining Mills.
Henzell—West Hallington Reservoir.
Jenkin—Some Applications of Electricity in Engineering Workshops.
Parkinson—Design of Railway Stations and Yards.
Wackrill—Short Method of Distributing Triangulation Errors.
Young—Deflection of Spiral Springs.
Andrews—Effect of Chilling on the Impact Resistance of Metals.
Donkin and Holliday—Calorimeters for Testing Fuels on a Small Scale.

From NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS, Newcastle-upon-Tyne.

Transactions—Volume XXXVIII, Part 4. Vol. XXXVIII, Part 5.
Report of the French Commission on the Use of Explosives in the Presence of Fire-Damp in Mines. 1890. Parts 1 and 2.

From the SOCIETY OF ENGINEERS, London, England.

Transactions for 1889. Bound.

From the LIVERPOOL ENGINEERING SOCIETY, Liverpool, Eng.

Transactions—Vols. IX, X and XI.
Reports XIV, XV and XVI, Sessions 1888.

From the SOCIETY OF CIVIL ENGINEERS, Paris.

Mémoires—Nov., Dec., 1889; Jan., Feb., Mar., April, May, June, July, Aug., Sept., Oct., Nov., 1890.

From L'ADMINISTRATION DES PONTS ET CHAUSSÉES, Paris.

Annales—Oct., Nov., Dec., 1889; Jan., Feb., Mar., April, May, June, July, Aug., Sept., Oct., 1890.
Personnel, 1890.

From the AUSTRIAN SOCIETY OF ENGINEERS AND ARCHITECTS, Vienna.

Wochenschrift.
Zeitschrift—Part 4, 1889, Part 1, 1890.
List of Members, May, 1890.

From the SAXON SOCIETY OF ENGINEERS AND ARCHITECTS, Leipzig.

Der Civilingenieur.

From the NORWEGIAN SOCIETY OF ENGINEERS AND ARCHITECTS, Kristiania.

Norsk Teknisk Tidsskrift, Part 6, 1889.
" " " Parts 1, 2, 3, 4, 5, 6, 1890.

From the SWEDISH SOCIETY OF CIVIL ENGINEERS, Stockholm.

Proceedings—Tredje Häftet, Fjerde Häftet, 1889.
Femte Häftet, Sjette Häftet, 1889.
Första Häftet, 1890.
Andra Häftet, 1890.

From the PORTUGUESE SOCIETY OF CIVIL ENGINEERS.

Revista de Obras Publicas E. Minas—Sept.-Oct., Nov.-Dec., 1889; Jan.-Feb., Mar.-April, May-June, July-Aug., Sept.-Oct., Nov.-Dec., 1890.

From the ASOCIACION DE INGENIEROS INDUSTRIALES, Barcelona, Spain.

Revista Tecnologico Industrial, 1889.

From the MINISTERO DEI LAVORI PUBBLICI, Rome, Italy.

Giornale del Genio Civile—Nov., Dec., 1889; Jan., Feb.-Mar., April, May-June, July-Aug., Sept., Oct.-Nov., 1890.

From the ARGENTINE SCIENTIFIC SOCIETY, Buenos Aires.

Annales—Sept., Oct., Nov., Dec., 1889; Jan., Feb., Mar., April, May, June, July, Aug., Sept., Oct., Nov., Dec., 1890.
General Index—1876-1889.

From the VICTORIAN INSTITUTE OF ENGINEERS, Melbourne.

Rules for Electrical Installations, 1889.

From the CANADIAN SOCIETY OF CIVIL ENGINEERS, Montreal.

Transactions—Vol. III. Part II. Oct. to Dec., 1890.
Transactions—Vol. IV. Part I. Jan. to June, 1890.
Charter, By-Laws and List of Members, 1890.

From the GEOLOGICAL AND NATURAL HISTORY SURVEY OF CANADA, Montreal.

Annual Report with Maps. Vol. III (New Series). Parts I and II. 1887–88.
Part M, Annual Report 1887. Sheet No. 17, N. E. New Brunswick.
Part K, Annual Report 1887. Plan of Asbestos Areas.

From the ASSOCIATION OF DOMINION LAND SURVEYORS, Ottawa, Canada.

Proceedings—Seventh Annual Meeting held at Ottawa, Feb. 18th and 19th, 1890.

From the HISTORICAL AND SCIENTIFIC SOCIETY OF MANITOBA, Winnipeg.

Annual Report for 1889.
Bryce—Two Provisional Governments in Manitoba.
Macfarlane—Land and Sea Birds.
Bell—Continuation of Henry's Journal.

From ENGINEERING ASSOCIATION OF NEW SOUTH WALES, Sydney.

Minutes of Proceedings, By-Laws and List of Members. Vol. III. 1888. Bound.

From the AMERICAN SOCIETY OF CIVIL ENGINEERS, New York.

Transactions—Oct., Nov., Dec., 1889; Jan., Feb., March, April, May, June, July, Aug., Sept., Oct., Nov., 1890.
Constitution, List of Members, 1890.

From the AMERICAN INSTITUTE OF MINING ENGINEERS, New York.

Transactions—Advance Sheets.
List of Officers, Members, Rules, etc., May, 1890.
Transactions—Vol. XVIII.

From the AMERICAN SOCIETY OF MECHANICAL ENGINEERS, New York.

Transactions—Vol. X, 1889. Vol. XI, 1890.

From the ASSOCIATION OF ENGINEERING SOCIETIES, New York.

Journal—Jan., Feb., March, April, May, June, July, Aug., Sept., Oct., Nov., Dec., 1890.

From the AMERICAN IRON AND STEEL ASSOCIATION, Philadelphia.

Annual Statistical Report for 1889.
Metal Schedule of the Tariff Act of 1890 compared with the Old Tariff Law, with Index.
Stebbens—Farm Mortgages.
Kennedy—Trusts and the Tariff.
Tariff Tracts Nos. 3, 4, 5 and 6—1890.

From the U. S. ASSOCIATION OF CHARCOAL IRON WORKERS.

Journal—Vol. VIII, No. 6.

From the WESTERN SOCIETY OF ENGINEERS.

Proceedings—Minutes of Meeting, 1890.

From the ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA.

Advance Sheets.
Proceedings—Vol. V. 1889.

From the BOSTON SOCIETY OF CIVIL ENGINEERS, Boston, Mass.

Constitution and By-Laws, 1890.
Constitution and By-Laws and List of Members, April, 1890.

From the AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, New York.

Transactions—Dec., 1889. Jan., Feb., March, April, June-July, Aug.-Sept., Oct., Nov., 1890.

From the TECHNICAL SOCIETY OF THE PACIFIC COAST.
Transactions—June, May-Sept. (Nov.-Dec., 1889, and Jan., 1890). Jan.-March, April, May-July, 1890. Aug., 1890.

From the ILLINOIS SOCIETY OF ENGINEERS AND SURVEYORS, Mr. S. A. Bullard, Secretary and Treasurer, Springfield, Ill.
Report of the Fifth Annual Meeting, held at Peoria, Ill., Jan. 29th-31st, 1890.

From the AMERICAN WATER WORKS ASSOCIATION, Elmira, N. Y.
Proceedings of Ninth Annual Meeting, held at Louisville, Ky., April 16th, 1889.
Proceedings of Tenth Annual Meeting, held at Chicago, Ill., May 20th, 21st and 22d, 1890.

From the ENGINEERING SOCIETY OF LEHIGH UNIVERSITY, Bethlehem, Pa.
Journal—Feb., April, June, 1890.

From the MISSOURI SCHOOL OF MINES, Rolla, Mo.
Scientiæ Baccalaureus, June, Oct., 1890.

From the MASTER CAR BUILDERS' ASSOCIATION.
Report of Twenty-fourth Annual Convention, held at Old Point Comfort, Va., June 10th, 11th and 12th, 1890.

From the NEW YORK ACADEMY OF SCIENCES, New York.
Transactions—Vol. IX, 1 and 2, 3-4, 5, 6-7, 8, 1889-90.
Annals—Vol. V, Nos. 4, 5, 6, 7-8.

From the DENVER SOCIETY OF CIVIL ENGINEERS AND ARCHITECTS, Denver, Colorado.
List of Members, Constitution and By-Laws and President's Annual Address, 1890.

From the MERIDEN SCIENTIFIC ASSOCIATION, Meriden, Conn.
Transactions—Vol. III. 1887-1888.

From ENGINEERING ASSOCIATION OF THE SOUTHWEST, Nashville, Tenn.
Constitution, List of Officers and Original Members, Jan. 1st, 1890.

From the NATIONAL ASSOCIATION OF BUILDERS, Boston, Mass.
Report—Fourth Annual Convention, held at St. Paul, Jan. 27th, 28th and 29th, 1890.

From the CIVIL ENGINEERS' CLUB OF CLEVELAND, Ohio.
Annual Register, 1890-91.

From the ENGINEERS' CLUB OF ST. LOUIS, St. Louis, Mo.
Constitution, By-Laws, List of Members and Programme for 1890.

From the ENGINEERS' CLUB OF KANSAS CITY, Mo.
List of Members—Feb., 1890.

From the ENGINEERS' CLUB OF CINCINNATI, Ohio.
President's Address, Dec. 19th, 1889.

From the MASSACHUSETTS INSTITUTE OF TECHNOLOGY, Boston, Mass.
Technology Quarterly—Feb., May, Aug., 1890.
Abstract of the Proceedings of the Society of Arts, 1889-1890.

From the WAGNER FREE INSTITUTE OF SCIENCE OF PHILADELPHIA, Montgomery Ave. and 17th St., Phila.
Transactions—Dec., 1889. Aug., 1890.

From the IMPERIAL UNIVERSITY OF JAPAN, Tokio, Japan, Mr. H. Kato, President.
Calendar for 1889-90.

From the AMERICAN PHILOSOPHICAL SOCIETY, Philadelphia.
Proceedings—No. 130, July to Dec., 1889. No. 131, Nov. 21st, 1889. No. 132, Jan. to June, 1890. No. 133, April 17th, 1890.

From the FRANKLIN INSTITUTE, Philada.
Journal—Jan., Feb., March, April, May, June, July, Aug., Sept., Oct., Nov., Dec., 1890; Jan., 1891.
Memoir of Frederic Graff.

From the PHILADELPHIA SOCIAL SCIENCE ASSOCIATION, Philada.
Patten—Principles of Rational Taxation, 1889.

From the MARITIME CANAL COMPANY, OF NICARAGUA, New York.
The Maritime Ship Canal of Nicaragua, 1890.
Map of Distances.
Profile of Canal.
Bird's-eye View of Canal and Costa Rica.

From the NICARAGUA CANAL CONSTRUCTION COMPANY, 44 Wall Street, N. Y.
Copy of *Engineering News*, Sept. 14th, 1889, containing Profile Map of Nicaragua Interoceanic Ship Canal.
Copy of San Francisco *Journal of Commerce*, Feb. 6th, 1890.
Copy of New York *Mail and Express*, April 29th, 1890.

From the STEVENS INSTITUTE OF TECHNOLOGY, Hoboken, N. J.
The Stevens Indicator—Jan., April, July, Oct., 1890.

From the BOARD OF DIRECTORS OF TULARE IRRIGATION DISTRICT, Tulare, California.

Reports on the Projected Works of the Tulare Irrigation District, Tulare Co., California, May 6th, 1890.

From the LIBRARY COMPANY OF PHILADELPHIA.

Bulletin—Jan., Sept., 1890.

Report, Board of Directors, May, 1890.

From the BOSTON PUBLIC LIBRARY, Boston, Mass.

Bulletins—Aug., 1887 to May 1889, April 1890.

Thirty-eighth Annual Report, 1889.

Bulletin—July, 1890. Bulletin—Oct., 1890.

From the U. S. GEOLOGICAL SURVEY, Washington, D. C.

Bulletins—Nos. 54 to 57 inclusive.

Fontains—Potomac or Younger Mesozoic Flora, Part 1st, Text. Bound.

Fontaine—Potomac or Younger Mesozoic Flora, Part 2d, Plates. Bound.

Newberry—Paleozoic Fishes of North America. Bound.

Eighth Annual Report for 1886-'87, in two parts. Bound.

Bulletin—Nos. 58, 59, 60, 61, 63, 64, 66.

Day—Mineral Resources of the United States, 1888. Bound.

Gilbert—Lake Bonneville, 1890. Bound.

Ninth Annual Report for 1887-'88. Bound.

From the ENGINEER DEPARTMENT, U. S. A., Washington, D. C.

Annual Report of Chief of Engineers, 1889, in 4 parts. Bound.

From the U. S. NAVY DEPARTMENT, Washington, D. C.

Pilot Chart of North Atlantic Ocean, for Jan., Feb., March, April, May, June, July, Aug., Sept., Oct., Nov., Dec., 1890; Jan., '91, with Supplement.

Proceedings of the U. S. Naval Institute—Vol. XV, No. 4, 1889. Vol. XVI, Nos. 1, 2, 3, 4, 1890.

From the U. S. BUREAU OF EDUCATION, Washington, D. C.

Report of the Commissioners of Education, 1887-'88. Bound.

Circular of Information No. 2, 1889.

Morgan—Indian Education. Bulletin No. 1, 1889.

Smith—Honorary Degrees, etc. Bulletin No. 1, 1890.

Special Report on Public Libraries. Part II.

Circular of Information No. 1, 1890.

Wells, Kelly—English-Eskimo and Eskimo-English Vocabularies.

Circular of Information No. 3, 1889.

Circular of Information No. 3, 1890.

From the DEPARTMENT OF STATE, Washington, D. C.

Official Catalogue of the United States Exhibit Paris Exposition, 1889. Bound.

Reports of the International American Conference. 1890.

From the U. S. COAST AND GEODETIC SURVEY, Washington, D. C.

Report of Prof. T. C. Mendenhall on Weights and Measures, Sept. 16th, 1889.

Four Magnetic Charts for 1890.

Bulletins Nos. 14 to 17 inclusive, Bulletin No. 18.

From the SMITHSONIAN INSTITUTION, Washington, D. C.

U. S. Board on Geographic Names—Bulletin No. 1. Issued Dec. 31st, 1890.

From the DEPARTMENT OF THE INTERIOR, Washington, D. C.

Compendium of Tenth Census of United States—Parts I and II. Bound.

From the U. S. DEPARTMENT OF AGRICULTURE, Washington, D. C.

Tratman—Report on the Substitution of Metal for Wood in Railroad Ties, etc. 1890. 3 copies.

From the COMMISSIONER OF LABOR, Washington, D. C.

A Preliminary Report on the Cost of Production of Pig Iron, etc., together with letter from Hon. J. G. Carlisle, U. S. S. 1890.

From the INTERSTATE COMMERCE COMMISSION, Washington, D. C.

Third Annual Report—Dec. 1st, 1889. Bound.

From the GEOLOGICAL SURVEY OF NEW JERSEY, Mr. Irving S. Upson, Asst. in charge, New Brunswick, N. J.

Annual Report of State Geologist for Year 1889. Vol. II, Part 1 of the Final Report. Bound. Vol. II, Part 2. 1889-90. Bound.

From the GEOLOGICAL SURVEY OF PENNSYLVANIA.

Southern Anthracite Atlas, Part II. Bound.

Eastern Middle Atlas, Part III. Bound.

Northern Anthracite Atlas, Part V. Bound.

Dictionary of Fossils, Vols. II, III. 1889. Bound.

Atlas of Southern Anthr it Field, Part III. Bound.

Oil and Gas Region, 1890. Bound.

From the FAIRMOUNT PARK ART ASSOCIATION, Philadelphia.

Seventeenth Report of Board of Trustees and List of Members. 1890.

From the COMMISSIONERS FOR THE ERECTION OF THE PUBLIC BUILDINGS, Philadelphia.

Contract for Metal Work of Clock Tower, with Reports of Architect and Special Committee on same, Sept. 24th, 1889.

From the BALDWIN LOCOMOTIVE WORKS, Philadelphia.
Milne—Vibration of Railway Trains.

From the PENN CLUB, 720 Locust Street, Philadelphia, Pa.
Charter and By-Laws, with List of Members for 1890. Bound.

From the author, MR. THEODORE COOPER, C. E., 35 Broadway, N. Y.
American Railroad Bridges. Bound.

From MR. J. J. R. CROES, C. E., 18 William Street, N. Y.
Report of Commissioners on Sources of Water Supply for City of Syracuse, N. Y.
Report on Extent of the First Works to be Constructed for Supplying Water to Syracuse, N. Y., by J. J. R. Croes, C. E., Nov. 11th, 1889. Revised.
Report on Skaneateles Lake Water Supply.

From GEN'L ROB'T P. DECHERT, City Controller, Philadelphia.
Annual Statement, Sept. 1st, 1890.

From MR. WILLIAM HAMILTON, Superintendent Toronto Water Works, Toronto, Canada.
Annual Report for Year Ending Dec. 31st, 1889.

From MR. JOHN KENNEDY, Chief Engineer.
Annual Report of Harbor Commissioners of Montreal, for 1889.

From MR. WM. KENT, M. E., Consulting Engineer, Room 125, *Times* Building, N. Y.
A Thirty-Years' Retrospect of the Iron Trade.

From MR. A. D. MARBLE, Acting City Engineer, Lawrence, Mass.
Twelfth Annual Report of City Engineer for City of Lawrence, for Year Ending 1889.

From the author, MR. WM. PIERSON JUDSON, Oswego, N. Y.
From the West and Northwest to the Sea by way of the Niagara Ship Canal. 1890. Bound.

From MR. ROBERT P. PORTER, Supt. of Census, Washington, D. C.
Bulletin No. 13. Production of Steel.

From MR. F. C. PRINDLE, C. E., U. S. N.
Lamb—Comparative Value of Heart and Sap Pine;
and Brown—Relative Strength of Heart and Sap Pine. 1890.
Water Treatment Tests.

From MR. AUGUSTUS SCHOONMAKER, Member Interstate Commerce Commission, Washington, D. C.
Third Annual Report of the Interstate Commerce Commission. 1889. Bound.

From MR. WM. M. SWEET, Special Agent 11th Census, 261 S. Fourth St., Phila.
Census Bulletin No. 9, August 20th, 1890.

From MR. HENRY R. TOWNE, Stamford, Conn.
Thurston—Efficiency of Chain Blocks.

From MR. ARTHUR WINSLOW, State Geologist, Jefferson City, Mo.
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ADDITIONS TO EXCHANGE LIST.

MERIDEN SCIENTIFIC ASSOCIATION, Meriden, Conn.
ENGINEERING ASSOCIATION OF THE SOUTHWEST, Nashville, Tenn.
THE STREET RAILWAY JOURNAL, N. Y.
THE ENGINEERS' CLUB OF CINCINNATI, P. O. Box 333, Cincinnati, Ohio.

Very truly yours,
H. W. Spangler.

PRESIDENT DURING THE THIRTEENTH YEAR OF THE CLUB, A.D. 1890.

PROCEEDINGS

OF THE

ENGINEERS' CLUB OF PHILADELPHIA.

ORGANIZED DECEMBER 17th, 1877.

NOTE.—The Club, as a body, is not responsible for the statements and opinions advanced in its publications.

Vol. VIII.] APRIL, 1891. [No. 2.

ANNUAL ADDRESS

OF

H. W. SPANGLER, Retiring President.

Read January 10, 1891.

MEMBERS OF THE ENGINEERS' CLUB:

GENTLEMEN—At the close of this, the thirteenth year of the Club's existence, it devolves upon me to call your attention to a few of the engineering features of prominence which have occurred during the year just passed.

In each line of engineering work, those of us who are especially interested have, through their own connections and the technical journals, a much broader and more exact knowledge of such features than could be given in the short length of this address, which can only be a summary of the year's work, and which must, of necessity, be largely drawn from such journals.

Perhaps one of the most striking events of the year has been the visit of the large body of foreign engineers to this country, which occurred in the Fall. The meetings for the discussion of technical subjects, the long railroad journey of over 4,000 miles

through the busiest parts of this country, and the reception accorded them by our people everywhere, have fully met their expectations and have, we believe, sent them home with the feeling that America is a good country to visit.

The able handling of such a large party, and the ready assistance of members of all the local and national societies, have, it is to be hoped, proved that there is little necessity for the affiliation of engineering societies, which has been talked of on the score of presenting a united body of American engineers in their intercourse with those of other nations. The advantages to be obtained by such a society as ours affiliating itself with any or all of the national societies are difficult to see; and although most of our members are now connected with one or more of the national societies, it is to be hoped that every effort will be made to prevent what would be simply the formation of another society, which, in its practical working, would in no way aid in the professional or personal advancement of the members of the local societies.

The recent trip of the U. S. S. Baltimore, carrying the remains of Ericsson from New York to Sweden, was a graceful act on the part of the United States Government, and the proposal that the United States should recognize the great services that he rendered us in our time of need is now before Congress, and should have the hearty support of every engineer in the country.

The opening of the new Forth Bridge, in March, marked the completion of one of the largest enterprises under way at the beginning of the year, and this is now the largest bridge-span in the world. The proposed bridges over the Hudson River—one known as the North River Suspension Bridge, and the other as the New York and New Jersey Bridge, are new enterprises in this line which have become prominent during the year. The latter structure proposes to cross the Hudson between Seventieth and Seventy-first Streets, and to be carried in the city to Thirty-eighth Street and Broadway, to a central depot 1,300 x 260 feet. The general details are for an eight-track bridge of a half-mile span, to cost in the neighborhood of $40,000,000.

The Panama Canal is practically abandoned, and reports from Colon show that the excavations made on the sides of the hills

are rapidly filling up. Attempts to arrange with the Colombian Government for an extension of the concession are still being made, but will probably fall through. The latest proposition to utilize part of the work is to build a ship-railway over sixteen miles of it, at a cost of $50,000,000.

The latest reports from Nicaragua are very satisfactory. Work on the bar at Greytown has commenced, and on the first level of the canal. There are 12 feet of water over the bar, and, in a short time, 20 feet will probably be reached.

The final plans are completed, and over 100,000 cubic yards of canal excavated. Five of the Panama dredges are on the ground and now at work. The railway is being rapidly completed. $1,104,500 of the capital stock has been paid in. Work and material, until about December 1, had cost $772,000 and $2,000,000 of the capital stock, and the company was then obligated from $4,286,000 of its first-mortgage bonds. Cash liabilities were $50,000.

The Florida Canal scheme is being actively pushed, and proposes a canal from St. Augustine, on the Atlantic, to Cedar Keys, on the Gulf Coast, to be 117 miles long by 28 feet deep and 200 to 250 feet wide.

The Commissioners have decided to report favorably to the Legislature of Pennsylvania on the plan of a connecting canal between Lake Erie and the Ohio River. The total lockage is 730 feet in 125 miles, which is to be overcome by 39 locks. The cost of a 12-feet-deep canal is $23,000,000, and the United States Government is to be asked to aid in the building and also to improve the Ohio River. The canal, as proposed, would accommodate boats of 1,500 to 2,000 tons, and it is expected that 50 cents per ton could be saved annually on 5,000,000 tons of coal, coke and iron passing between Pittsburgh and the Lakes.

The Mussel Shoal Canal, which has been twenty-five years in building, is at last completed, and makes Florence, Ala., the head of navigation on the Tennessee.

The annual report of De Lesseps shows that the gross receipts from the Suez Canal have reached the large total of $13,800,000, and the expenditures, including interest account, have amounted to $6,400,000, leaving $7,400,000 for dividends. Extensions and

renewals, costing $1,920,000, have been made. The depth of water maintained is 26 feet. During the year 1889–90, 3,425 vessels, of 6,783,187 tonnage have passed through, yielding a revenue of $12,882,400. Since the installation of the electric light plant, 71 per cent. of the vessels have passed through at night.

The Chignecto Ship Railway is being rapidly completed. A rather novel method of constructing the bridge over the Tidnish River has been adopted. The bridge was constructed, and, after being finished, the course of the river was changed to pass under the bridge.

The building of the Quaker Bridge Dam, which has given rise to so much discussion in this and other engineering societies, has been definitely abandoned, and in its stead a dam of less than half its cost is to be erected, which, with the storage capacity provided for under the new plans, will give 200 days' supply of 250,000,000 gallons each, and any further supply for New York City will probably have to be looked for elsewhere.

The selection of Chicago as the city in which to hold the World's Fair in 1893, and the issuance of the President's proclamation inviting the world to take part, has formally launched that enterprise. If the Fair is to be worthy of the country and the times, the most strenuous exertion on the part of all those concerned will be necessary to do the immense amount of work required in the comparatively short time yet remaining.

The proposed International Engineering Congress, to be held during the Exposition, promises to be of great value to the engineering profession. The late International Meeting of Mining and Metallurgical Engineers proved that such a congress can be made of immense value, and in interest and permanent benefit the proposed congress will probably stand far in advance of any engineering meeting ever before held.

The wonderful advance made by this country in the production of iron and steel in the last ten years is an evidence of the growth of the material prosperity of the country.

In the census year 1880 the total amount of pig-iron produced in the United States was 3,781,021 tons, while in 1890 this had increased to 9,579,779 tons. Of this quantity, Pennsylvania had produced 51 per cent. in 1880, and 49.19 per cent. in 1890.

That better methods have been universally introduced is seen from the fact that the number of completed furnaces has fallen from 681 to 562. Much of the increased production has been with coke and bituminous coal, which has increased over 300 per cent. in the ten years.

The production of steel has shown an equally large increase, the total quantity increasing from 1,145,711 tons in 1880 to 4,466,926 tons in 1890. Of this large amount, the three States of Pennsylvania, Ohio and Illinois made over 91 per cent. in 1890. The manufacture of steel rails has grown in about the same proportion—from 741,475 tons in 1880 to 2,036,654 tons in 1890. As in the case of pig-iron, the number of establishments making steel rails is little, if any, in excess of what it was ten years ago, but the size and efficiency of the plants have been wonderfully increased.

Most of the new establishments have been built for the purpose of making steel for other than rail purposes. The prominence given the Darby process, by which tool steel can be produced from the Bessemer converter by bringing the liquid metal into contact with solid carbon, was one of the interesting results of the late International Engineering meetings.

The recent tests of armor plate, carried out at the Government proving grounds, have given considerable prominence to the manufacture of nickel steel, which gave the best results in those tests. Experiments have been carried on for several years in England, but it was not till 1887 that any results at all satisfactory were obtained. At that time a steel was produced which had a tensile strength of from 90 to 97 tons per square inch, with from 8 to 7 per cent. elongation. Since that time numerous tests have been carried out, some of which agreed with, and some gave different results from, those at Annapolis. As a result of these experiments, $1,000,000 has been appropriated for material of this kind by Congress. The appropriation of such a sum on the results of a trial of a single plate seems to be a case of deciding on very incomplete data. Several concerns in the United States have made nickel steel, that made at Homestead being on a large scale. Specimens from a ¾-inch plate gave a tensile strength of 100,000 to 102,000 pounds per square inch, with an elastic limit

of 59,000 to 60,000. The Navy Department has ordered trial plates.

Other experiments, made by Mr. Harrington, of Allegheny, from spring steel stock, of 60,000 to 68,000 pounds per square inch, cast in 90-pound ingots, gave 153,350 pounds per square inch tensile strength, with 92,020 pounds elastic limit and an elongation of 2.5 per cent. in 2 inches. The increased cost of the material was about a quarter cent per pound. The prominence into which nickel has sprung has shown that there are not over a dozen mines in the world from which it is obtained, only two being in the United States, one in Nevada and one in Lancaster County, Pa.

The progress made in the construction of the new navy is encouraging. There are now 8 vessels, of 23,682 tons, in active service, of which 4, of 14,900 tons, were built in this city. There are four others, of 11,298 tons, which have had or are about to have their trial trips. Four others, of 17,505 tons, are well under way—the Maine, of 6,648 tons, has been launched; and the Texas, of 6,314 tons, and the Monterey, of 4,000 tons, are almost ready, and 5 cruisers and 3 battle-ships are now in the contractors' hands.

The three battle-ships contracted for a short time since are the most powerful vessels of the new navy, having a displacement of 9,000 tons. They will be driven at 15 knots by engines of 9,000 horse-power. It is particularly gratifying to know that the later vessels, both in hulls and engines, are of American design, and that, while designed to be the equivalent of any vessel of their class in the world, have, in almost every case, exceeded the requirements of the specifications.

The amount of railway construction during the year has not been particularly noticeable, about 6,000 miles having been laid, as against double the distance three years ago. Most of the construction has been in the direction of new lines, opening up new and valuable territory, rather than the construction of competing lines, and much of this has been in the South and Southwest.

The first meeting of the Commissioners of the Inter-continental Railway, consisting of representatives from the American Republics, has been held in Washington, and some feasible plan

of connecting North and South America by rail is expected as the result of their deliberations.

Trials are being made, both in this country and abroad, on compound locomotives, and the reports are not particularly in favor of the compound engines. A test, carried on for six months with 5 simple and 5 compound locomotives, showed that the compound locomotives used 29.2 pounds of coal per locomotive mile, while the simple engine used 30.9, or a saving of 5.5 per cent. Tests made in France show that the compound engine saved 7.24 per cent. per mile, or 19.92 per cent. per ton mile over the simple engine in coal burned, and the results of the tests recently carried on on the B. and O. Road show that the average amount of water used per i. h. p. was about the same in both cases. The report stated that the compound engine used 14.9 per cent. less coal and 3.2 per cent. less water than the standard engine, but only 5 per cent. of the saving was due to the engine.

While several schemes for facilitating transportation between New York City and Jersey City and Brooklyn by bridges are in contemplation, connection by tunnel is promised in the near future. The necessary legal authority for the construction of the East River Tunnel has been obtained, to connect the Long Island Railroad with the Forty-second Street Station.

The plan proposed is for a tunnel excavated 100 feet below the surface, to be 27 feet wide by 22½ feet high. Electric motive power is to be used at an estimated cost of $1,000,000. The Hudson River Tunnel is being pushed forward as rapidly as possible from the New Jersey side, and on November 1, 350 feet of iron tunnel had been completed, in addition to the reconstructed portion of the old one.

The Wiman Tunnel, between Staten Island and Long Island, has reached that stage that a bill to authorize the construction has been introduced in Congress. The termini are to be Stapleton and Bay Ridge.

The progress that has been made in the manufacture of aluminium promises soon to bring that metal strongly into competition with several of the cheaper metals. The late reduction to $2 per pound in large quantities, and the reduction to $1 per pound in alloys, has already largely increased the field of its usefulness, and

the ready sale found for the entire output is all that prevents still further reduction in price. Both the Pittsburgh Reduction Company and the Cowles Smelting Company have in contemplation a large increase in plant, which will probably reduce the cost materially.

At 50 cents per pound it will become a strong competitor of copper at present rates. The present output of the Pittsburgh Company is about 375 pounds per day, requiring in the neighborhood of 500 horse-power. An increase in production to 5 tons per day will probably require 13,000 horse-power. The difficulty of brazing has prevented its use in many instances, but it has been found that an alloy of 10 parts of aluminium and 1 part of tin can be soldered without difficulty. The alloy is of a paler color, has a specific gravity of 2.85, and is not so readily acted upon by reagents, and can be more readily worked than the pure aluminium.

The combination of aluminium with steel does not promise to be of very great moment. Careful investigation has shown that it may be used with high carbon steels in producing soundness, and its particular advantage, outside of its possible non-corrosive effect, is that in itself it combines the advantages of both silica and manganese.

The increasing scarcity of platinum, due to its increased cost of production and its greatly increasing use in incandescent lamps, has increased its value over 100 per cent. in the year, and over 33 per cent. in the last six months. Attempts which are being made to obtain a substitute for it for electrical purposes have, so far, been unsuccessful.

Two new processes for the production of tubes of steel and copper, which have been in the experimental stage for some time, have attained considerable prominence during the year. The method of making copper tubes and vessels by electro-deposition is being successfully applied. The copper is deposited from rough bars upon a revolving mandrel or mold, over which a burnisher moves, condensing the copper particles and rendering the material dense and with a uniformity of strength heretofore unknown. While ordinary copper has a tensile strength of 31,000 pounds, or less, tests made of electrically deposited copper gave 58,000 to

60,000 pounds tensile strength, with an elongation of 14 to 17.5 per cent., and a reduction of area of from 66 to 70 per cent.

The manufacture of Mannesmann tubes promises to become an extensive industry. By an ingenious arrangement of rolls the metal is drawn out from the surface of the bar, leaving the desired opening through the center, forming a tube of any size or thickness desired.

A few years since, almost a revolution in the methods of manufacture took place in the western part of this State and in adjoining States, through the introduction of natural gas, and it now appears that an equally radical change must be made either back to coal or in the direction of the substitution of fuel gas or crude petroleum. While companies supplying gas claim that in many cases they are simply cutting off an unprofitable part of their business, reports of decreased pressure and failing supply are constantly appearing.

The making of artificial fuel gas promises, in this connection, to become important, and in Pittsburgh and vicinity a number of concerns are putting in plants for making gas on the Siemens-Anderson process. There are several instances of the supplying of fuel gas in the large cities for household purposes, and it is believed that this can be done profitably in any of the larger cities. In Boston the Boston Gaslight Company supplies fuel gas in certain districts at 60 cents net per 1,000 feet, while in Chicago the company controls 42 miles of mains, and claims to be selling gas at 50 cents per 1,000 feet to over 3,000 consumers.

Any of the better class of gas engines can develop power at a cheaper cost with gas at 60 cents per 1,000 than can be done in any other way, and the manufacture of gas engines will be greatly benefited by the extension of cheap gas

The attempt is being made to render available some of the power of Niagara Falls. A tunnel of 490 square feet in section, and nearly rectangular in shape, is to be run from a point below the Falls to about 2½ miles above the Falls. Starting a short distance below the Falls, with the bottom of the outlet 20 feet below the mean water level, the tunnel will extend to a point a mile above the Falls, and 400 feet from the river, in a straight line, with a slope of 7 feet to the thousand. From this point it will

continue parallel to the bank for $1\frac{1}{2}$ miles, at a depth of 160 feet below the surface.

The works are designed to develop 120,000 horse-power, to be transmitted to various points as may hereafter be determined. Shafts have been sunk to a depth of 200 feet, and a portal incline begun, and much of the necessary plant for carrying on the work is on the ground.

The Missouri Water Power Company have commenced the construction of a dam across the Missouri near Helena, Mon., to develop 20,000 horse-power by means of turbines, to be transmitted electrically 13 miles to Helena.

Engineering estimates for the Sault Ste. Marie water-power showed that 90,000 cubic feet of water was available, with 18.5 feet head. To furnish 10,000 horse-power, $125,000 will be required.

The construction of Diamond Shoal Light House, the contract for which was entered with this year, will be of extreme importance to our coastwise shipping. The foundations are to be formed by sinking a large caisson, built in solidly with concrete, and the contract price for the structure is $485,000.

In the domain of electricity the year has been spent rather in the direction of the perfection of details and the application of what we already have, than in the discovery or invention of any great novelty. In our local telephone service we still get the same bad service as a year ago; incandescent lights are still run at a higher voltage than they were designed for, if we pay for them, and at a lower voltage if the company replaces them. The overhead trolley system is getting more and more of our cities into its grasp, to the great disgust of the people, who have for so many years been attempting to put all wires under ground; and, generally, electricity seems to be becoming our master rather than our servant. Of course much of this is preventable, which means the expenditure of money enough to allow the electrical installation to be made in the best manner.

The number of light and power stations and of isolated plants is rapidly increasing, and in a short time, in most of our cities, electricity will be universally available.

Rapid transit on surface lines is really becoming rapid transit,

solely by the aid of electricity, and the year has seen a large increase in the number of electric railways and several new systems put into operation. The reported adoption of the storage battery car in Washington seems to be the beginning of the use of what is probably the best system that can be devised.

The almost universal adoption of electricity for small powers, in districts where available, will probably be the result of the application of motors designed for all classes of work. The use of electricity for heating purposes is making little progress, and it will probably be a long time before a commercial success can be made of it.

The development of electric welding is being rapidly pushed forward, and while it is becoming of greater utility, there are difficulties in the way of its universal application, which will probably take a long time to surmount.

Some of the applications of electricity to power transmission and metallurgical processes have been already spoken of, and it promises to be of immense service to the chemist for analytical purposes.

The long-distance telephone lines are being rapidly extended, and, in general, the service is excellent, and when some of the care taken on these lines is extended to local service there will probably be little to complain of.

In our own city the engineering progress made has not been remarkable, but much is promised for the near future. Our water supply is becoming more satisfactory, our gas is becoming less so, while the patchwork system still prevails in taking care of our streets. Rapid transit by cable is not a success, and it is to be hoped that in a short time a large part of one's time need not be spent in street cars.

The probable erection of an elevated railroad on Market Street will add much to the convenience of West Philadelphia, but as much of the travel in the city is north and south, no scheme will give the city what it needs in the way of rapid transit which does not fully provide for travel in both directions.

It seems to be a great misfortune that some system of subway rapid transit, operated, lighted and ventilated by electricity, cannot be introduced, which would enable our city to take the first

rank among American cities for convenience and comfort of transit, at the same time doing away with the continual opening of our streets for electric lighting, gas, water, telegraph and sewer purposes.

The large price paid by the city for its electric lighting seems to be out of all proportion to the service rendered.

The dredging of the Delaware River in front of the city and the removal of the islands will add much to the advantage of Philadelphia as a shipping port, and prepare us well for that revival of our shipping interest which is likely to follow the activity of the Government in building vessels of war.

The completion of League Island as a great naval station, although proceeding very slowly, will probably be pushed rapidly within the next few years, as the necessity of a fresh-water yard for the new ships becomes more strongly felt.

In these days of new enterprises, new applications of well-known forces and new discoveries in scientific lines, which can be directly applied to the improvement of business and social conditions, it is, perhaps, of interest to look over the educational question connected therewith and examine, for a short time, the equipment that men who are to take advantage of these new discoveries and adaptations, and are to apply them to the needs of everyday life, are provided with by the institutions which are giving technical instruction, and to look, for a time, at what would constitute a course in technical instruction.

In general, technical instruction, in the sense in which we use it, is understood to mean one of two things—either instruction in those matters pertaining to one of the many divisions of engineering, or instruction pertaining to one of the various trades or businesses; and while the two divisions overlap each other, sometimes so far as to be inseparable, the aims of the two courses of instruction are entirely different. The one is intended to furnish a broad general training, which may serve as a basis for work in any of the special branches into which engineering is divided; while the other is almost entirely devoted to training the man in one special branch of work.

A few years ago an engineering education was incomplete which did not give a man the principles underlying steam, hy-

draulic, electrical, railroad and marine engineering, while to-day courses of instruction are established, nominally at least, in each of these branches, but in reality a course in one branch is incomplete which does not give the underlying principles of all the others.

One cannot fail to be impressed with the magnitude of the demand for such education by a simple statement of the number of institutions engaged in technical work, and the number of students now studying such subjects as Civil, Mining, Electrical or Mechanical Engineering in our own neighborhood.

In Pennsylvania alone there are not less than 7 institutions, having 884 students studying technical subjects, while in New Jersey there are 3 having 368 students, and in New York there are 4 prominent schools having 882 pupils, or making, in these three States, 14 schools, having 2,000 students pursuing technical courses.

As to just what *should* constitute a technical education, opinions differ somewhat, but as to just what *does* constitute such an education, there are nearly as many opinions as there are institutions.

In its broadest sense, a technical education is an education which pertains to a particular profession. It will be noted that the training is a particular one, and does not cover what is generally understood as a liberal education. That this is, to a great extent, lost sight of in planning a course of instruction in a technical subject is to be found from even a hurried examination of the subjects taught in many technical schools.

One institution will be found which teaches in its Engineering course, History of the English Language, English Literature, Political History, European History, Political Economy and, among its exercises, Military Drill. Several add to this list Logic or Astronomy, and it is not unusual to find almost any subject made part of an engineering course among the minor institutions.

That these subjects are part of a technical training, no one will claim, but that they are desirable to know goes without saying. The fact that it is training in a particular line is overlooked, and a liberal education and a technical education are combined to the disadvantage of both.

To benefit by a technical course, a certain amount of maturity is

necessary, and that course of instruction which allows the technical work to follow a liberal education is, of course, the very best way of obtaining all that any educational course can give. This, however, is a very difficult course to pursue in this country, as there are very few who can take two courses in college—which is what the above implies—unless a course is so arranged that the liberal studies precede the technical.

As it results, therefore, that in many cases the student has only time enough to pursue one or the other of the two courses, is it desirable to make such a course partake of both characters? It seems to me not. All the benefit the student will get from the liberal studies (so called) will be a mind-training or disciplining, which can be equally well obtained from following a technical course.

A training which is to last through one, two or three years, as the case may be, and to be thereafter dropped and the subject-matter forgotten, cannot be as lasting in its benefits as one which, carried throughout college, is the foundation on which all the after-work of the engineer is to be built. The broader and deeper this foundation can be laid the stronger may be the superstructure, and if it is not possible to have both—the so-called liberal training and the technical training—the latter is the more desirable if properly carried out.

It is essential that, before a student can undertake technical work, certain elementary work should be completed; and as to the nature of this work there may be considerable difference of opinion. Taking the subject of Mechanical Engineering alone, there can be little doubt as to the direction that the elementary education should have followed.

After beginning technical work, the lines of study are mathematical and physical, and, logically, the earlier training should have been in the same direction. It is a difficult matter to say *how much* of each should have been done.

It is not difficult, however, to say *how* each should be done. Well-grounded principles are much better than a large quantity of useless and often foolish applications, and any course of instruction which teaches how, rather than why, is, to a great extent, a failure. I do not mean that problems solved are not

of advantage, as it is only by the aid of well-selected problems that a thorough understanding of the underlying principles can be obtained.

It is in the preparatory schools that much of the language instruction should be done. And in no other place can a good knowledge of correct English be satisfactorily imparted, if it has not been done in the preparatory schools.

As already indicated, after technical instruction begins, it should follow two lines—mathematical and physical. There are two ways of following out each line of work; as, for instance, in mathematics, by making the course either a scientific study or a technical one. As a scientific study it is interesting, but of little use; while as a technical study it is liable not to be broad enough.

No work is well done if the principles underlying it are not thoroughly mastered. That any one familiar with the subject can teach it, is a mistake. A good general teacher of mathematics may be a poor teacher for a technical school, and an excellent physicist is often of little value to the engineering student. A judicious knowledge of what not to dwell upon is as indispensable as a knowledge of the subject itself. It is a mistake to believe that a student cannot have too much mathematics or too much physics in an engineering course. Almost invariably it is the other way. The student does have too much mathematics and too much physics in the sense of quantity and not enough in quality.

This, of course, may be the fault of the student, but it is as often the fault of the instructor. Principles well drilled into the student are what is needed, and unless this is done, many hours are wasted and the instruction is not a success.

Coming to the engineering end of the instruction, the special engineering training is simply the application of the principles taught to certain branches of actual work, supplemented by the practical examples that are germane to the subject.

It is here that the different branches of engineering separate, and the instruction of the student to this point should be such that his education is broad enough to allow him to pursue any branch of engineering work that he may desire.

The practical work that can be taught in an engineering course is, of course, limited, and should be of such a character as would give the most instruction to the student. Methods are what is desired, rather than results, and any system of practical work, to be of benefit to the student, must make him think for himself, must make him handle the difficulties that present themselves, and solve the problems for himself.

There are two kinds of practical work done in most technical schools—one going by the name of manual training, and one known as laboratory work. The laboratory work is what we have been speaking of. With regard to manual training, there are two entirely dissimilar views taken, one of which is that all the exercises should be educational, and that the object of the work done is to educate the hand in the direction of doing purely manual work. The other view is not so much the hand-training that is desired, as to give the student an insight into the methods actually used in carrying out mechanical processes. In a few cases both methods are combined; generally the latter is made the prominent feature.

It seems desirable that the educational feature of this work should be kept more fully in view; otherwise, much time is wasted in watching a machine do the work, with little benefit to the student. This brings up a question which is often asked and generally answered according to the especial training of the person to whom the question is put.

Is it desirable, when a shop-training and school-work can both be had, to take the school-training or the shop-work first? While there is something to be said in favor of either plan, that which can be urged against the shop-work first and school afterward is much the stronger.

Any system of education to be effective must be continuous. A boy goes to school until from 16 to 17 years of age, and then, say, into a mechanical establishment for three or four years. His methods of life and study are entirely changed, and he takes up work, the reasons for which come to him very slowly. At the end of three or four years he has lost much of the groundwork which he can use in his technical school, and has, in its stead, gained a knowledge of what would be advantageous for him to

know. Or he realizes what he requires, but his disuse of his studying faculties has, to a certain extent, deprived him of the means of obtaining that knowledge, or at least has rendered it very hard for him to do it.

You have also, in many cases, given him a distaste for book-learning, as he does not realize that about all he knows beyond his manual skill is to be found somewhere in books.

Following the other course, there is no break in the continuity of the young man's work; his previous preparation eminently fits him for a continuation of his studies, and while he probably cannot grasp the practical details as rapidly as the first, all his work is easier to him, and at the end of his course he is much better prepared to intelligently begin work in a manufacturing establishment than the other man at the same age would be to begin his studies.

His after-life would then always be a continuation of his early work in the shop, instead of having a break of four years, as in the other case, where the college follows the apprenticeship.

A few years ago it was considered sufficient to create a professorship in mechanical engineering and the course was successfully launched, but a short time generally was sufficient to show that something was wrong. Classes did not grow in size, and, after graduation, the students were not properly prepared for their life-work. The college course had been carried out in the old-fashioned way—much lecturing with very little individual instruction.

It soon became evident that a change was needed here; the number of instructors was increased, and classes were divided into smaller working sections. When this plan had been carried out, an immediate improvement was seen in the character of the work done.

Of course this meant increased cost, but this was only one of the necessary changes. Larger buildings and a large amount of costly apparatus became necessary. To procure testing apparatus of all kinds, large sums of money had to be spent, and the outlay per student has been far in excess of that for any other instruction having the same number of students. The advent of electrical engineering has made these expenses still heavier,

and to keep abreast of the times, the continual output of money is absolutely essential.

The bettering of the education of engineering students in the United States depends to a very great extent upon the engineers, and it is a matter of moment to us that those coming after us should be as well educated as the times will permit.

Many engineers are graduates of some of our technical schools, and a few years after graduation are competent to intelligently criticise the methods pursued at these institutions, but little criticism is made, and because of the need of such criticism many important changes which should be made are put off until too late.

While the technical schools are trying to do their work intelligibly, a much more generous assistance from engineers in active life is desirable, that they may be kept up to their highest standard of efficiency and well abreast of the times.

It is a mistake to believe that any man's methods cannot be improved upon, but it is only through intelligent criticism by intelligent engineers that such improvement can be brought about. But it must be remembered that any criticism to be effective must be accompanied by a working plan for improvement, and without such a plan, or without a realization of the needs of the student, taken together with the time in which the instruction must be given, criticism becomes simply fault-finding.

In conclusion, allow me to thank you for your uniform courtesy and consideration, and to express to you my best wishes for the future prosperity of the Club.

VIII.

DEMOLITION OF ROCKS UNDER WATER WITHOUT EXPOSIVES—LOBNITZ SYSTEM.

Translated from *Nouvelles Annales de la Construction*, March, 1890.

By Edwin S. Crawley, Active Member of the Club.

Read May 3d, 1890.

The methods of demolishing rocks by the use of explosives are always attended by a certain amount of danger, while at the same time there is always more or less uncertainty in regard to the final result of the operation. Especially is this the case when the work must be carried on without interrupting navigation and in the vicinity of constructions that may receive injury from the explosions.

Such were the conditions imposed in enlarging the Suez Canal in certain parts where the ordinary dredges could not be used.

Mr. Henry Lobnitz, engineer at Renfrew, has contrived a new method of procedure, designed for the purpose of enlarging and deepening the canal in those parts between the Bitter Lakes and Suez, where it runs over a rocky bed. It was necessary to execute the work without interrupting or obstructing traffic on the canal.

The principle of the system consists in producing a shattering of the rock by the action of a heavy mass let fall from a convenient height, and acting like a projectile of artillery upon the wall of a fortress.

From experiments made in the quarry of Craigmiller, near Edinburgh, with a weight of two tons, shod with a steel point, it was found that with a fall of about 5.5 meters (18.04 feet) there was broken up on an average more than 0.113 cubic meters (0.148 cubic yards) of hard rock per blow. The first blow, delivered 90 centimeters (2 feet 11½ inches) from the wall-face, produced an almost imperceptible rent, a second or a third blow applied at the same place extended this opening often to a length of 1.50 meters (4 feet 11 inches) and to a depth of from 90 to 120 centimeters (2 feet 11 inches to 3 feet 11 inches). The next blow opened the fissure and detached the block of rock.

The application of the same system under water upon an unknown surface would obviously modify the conditions of the experiment. Nevertheless, the results obtained with the "Dérocheuse," the first dredging machine constructed upon this principle, have realized the hopes of the inventor.

This dredging machine was launched on the Clyde and reached Port Said in twenty days. It measures 55 meters (180 feet 5 inches) in length, 12.20 meters (40 feet 1 inch) in breadth, and 3.65 meters (12 feet) in depth. Its mean draught of water is 2.75 meters (9 feet 2½ inches). It is divided into eighteen water-tight compartments. Five steel-pointed battering-rams, each of four tons weight, are arranged in line upon each side of the chain of buckets of the dredging machine. See Figs. 1 and 2. The battering-rams, suspended by chains, are raised by hydraulic power to a height varying from 1.50 to 6 meters (4 feet 11 inches to 19 feet 8 inches), and are then let fall upon the rock. The mechanism of the battering-rams is carried by a metallic

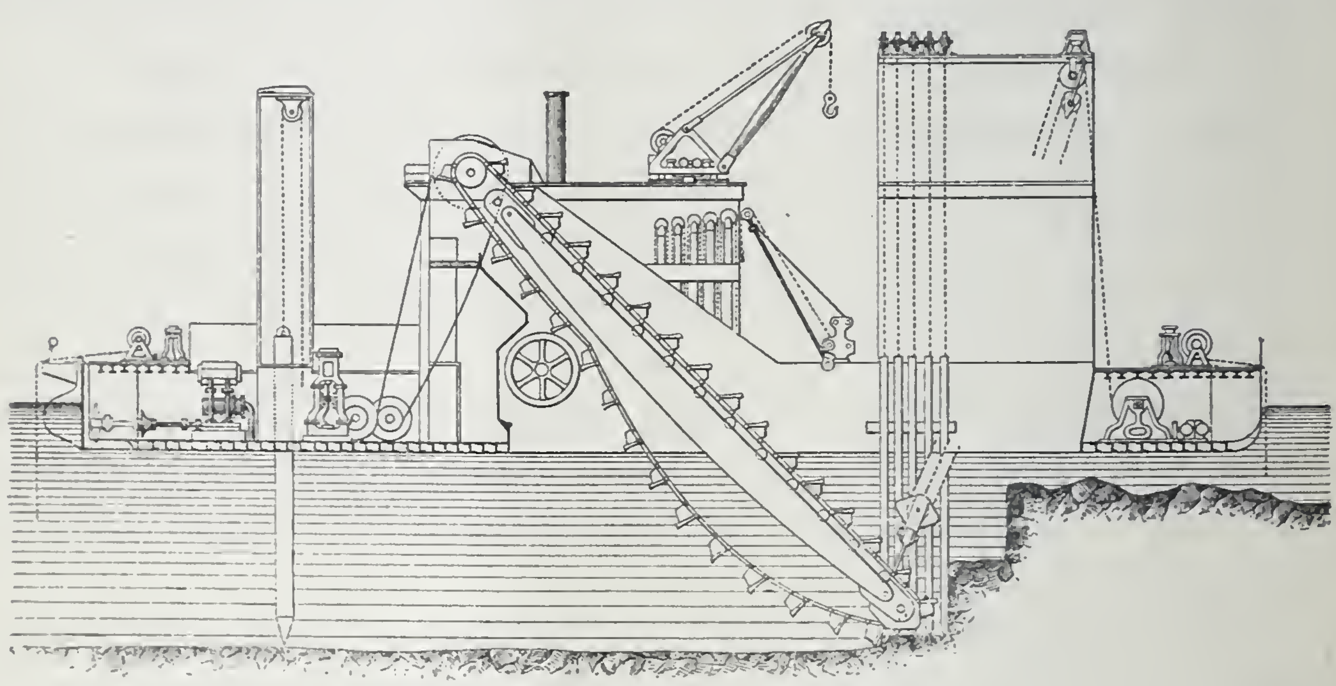


Fig. 1.—Longitudinal Section.

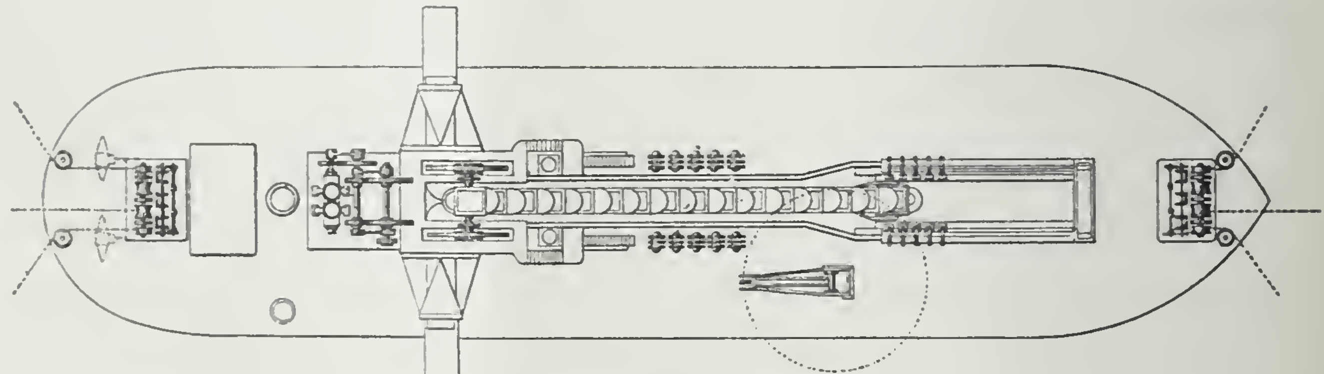


Fig. 2.—Plan.

cage which can be moved forward or backward by the aid of steam as the needs of the work require. A series of five battering-rams gives from 200 to 300 blows per hour.

A dredging machine, combined with the apparatus just described, raises the fragments of rock as they are detached from the bottom. A guide-wheel is provided, which supports the chain carrying the buckets, and thus diminishes the stress upon the axles and bearings. With this guide-wheel or auxiliary drum there is no difficulty in dredging to a depth of 12 meters (39 feet 4 inches), while without this accessory it is difficult to attain a depth of 9 meters (29 feet 6 inches).

A compound engine, with four cylinders of 200 indicated horse-power, drives, by means of friction gear, the chain which carries the buckets. If the buckets happen to strike against the rock, the friction gear yields until the excess of resistance has disappeared.

Figure 3 indicates the manner in which the dredge is operated during the work. It turns alternately about two spuds which are thrust successively into the bottom and about which the dredge describes a series of arcs in a zigzag fashion. These spuds are worked by hydraulic power.

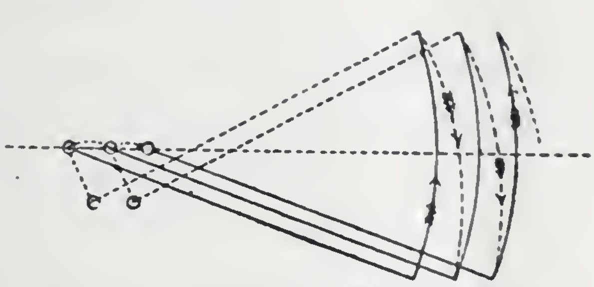


FIG. 3.—DREDGE MOVEMENT.

A three-ton hand crane is placed upon the bridge for use in making repairs to the chain which carries the buckets. A six-ton steam crane is placed upon the top of the cage which supports the hydraulic apparatus for raising the battering-rams, thus permitting them to be easily lifted and replaced.

The dredging machine is also furnished with two screws driven by an engine of 300 indicated horse-power, as well as with two independent boilers. Two independent series of pumps, with separate connections, feed the hydraulic lifting apparatus, thus permitting repairs to be made when necessary, without interrupting the work. A special machine with three cylinders drives the

pumps of the condenser. An accumulator regulates the hydraulic pressure and serves to raise or lower the spuds.

At the end of the Suez Canal next to the Red Sea, the bottom consists of various conglomerates containing gypsum, sandstone and sometimes shells. It was upon a bed of this varied nature that the machine was first put to work. The mean depth of water, originally 8.25 meters (26 feet 3 inches), was for a long time sufficient for the traffic of the canal; but as the variations in level of the Red Sea are from 1.8 to 3 meters (5 feet 11 inches to 9 feet 10 inches), the depth at the moment of low water is scarcely adequate for the constantly increasing draught of water of the steamers. Attempts were made to attack the rocky surface of the bottom with powerful dredges, but this method was expensive because it necessitated constant repairs to the dredges. These last, although of good construction, seldom raised more than 153 cubic meters (200 cubic yards) in from eight to fifteen days. Their daily advance was often only from sixty to ninety centimeters (about 2 to 3 feet), while with the "Dérocheuse," it was possible to advance ten times as rapidly in dredging to the same depth. The bottom upon which the machine commenced its work was clean and of a true rocky nature. It was soon perceived that this conglomerate, rich in gypsum, possessed too great elasticity for the pointed battering-rams to have their proper effect upon it. Each blow made a hole of from fifteen to sixty centimeters (6 inches to 2 feet) in depth. A second blow, given even very near to the first, formed a similar hole, leaving the bed of the rock to all appearances intact between the two holes. This result, due entirely to the special nature of the rock, led to the fear that the action of the battering-rams would be without effect. After some experimentation it was found that the best results were obtained by arranging the battering-rams very near to the chain of buckets and by working the dredge and battering-rams simultaneously. The advance at each oscillation was about 90 centimeters (about 3 feet).

The results obtained were as follows: At first the quantity extracted varied much from day to day; but at the end of some weeks, on account of the greater experience of the crew, more regularity was obtained. The nature of the conglomerate was

essentially variable, sometimes hard and tenacious, like malleable iron, then suddenly changing into friable masses surrounded by portions more elastic and richer in gypsum. During the last five weeks at Port Tewfick, the expense, including the repairs, was 8,850 francs ($1,770.00) for 1,600 cubic meters (2,093 cubic yards) extracted. This would make the cost 5.52 francs per cubic meter or $0.84 per cubic yard, not including the insurance, the interest and the depreciation of the plant.

After some improvements in details, suggested by practice, the machine was put in operation at Chalouf upon a hard rock, from 1.50 to 3 meters (4 feet 11 inches to 9 feet 10 inches) thick. The battering-rams were given a fall of 1.80 meters (5 feet 11 inches). To break the rock into fragments small enough not to be rejected by the buckets of the dredge, the operations of dredging and of disintegration were carried on separately, permitting the battering-rams to work at a greater distance from the wall-face. The time consumed in thus pulverizing the rock by repeated blows was naturally found to be increased. It was found more convenient to use only a single row of battering-rams. The production was from about seven to eleven cubic meters (9.2 to 14.4 cubic yards) per hour. Toward the close of September, after it had been demonstrated that the "Dérocheuse" was capable of accomplishing with celerity and economy the result for which it was designed, it was purchased by the Suez Canal Company.

During the month of September, an experiment, the details of which were carefully noted, extending over a period of sixteen days, gave the following results:

Crew (33 men), 140 hours,	2012.50 francs	$402.50
Coal, @ 37.50 francs ($7.50) per ton,	787.50 francs	157.50
Oil and supplies,	220.00 francs	44.00
Fresh water, 16 days,	210.00 francs	42.00
Sundries,	42.50 francs	8.50
Total expense for removing 764 cubic meters (999.2 cubic yards),	3,272.50 francs	$654.50

Average, 4.28 francs per cubic meter ($0.65 per cubic yard).

This result cannot be taken as a universal basis, because, after a year's use, there are numerous repairs to make to the plant,

which would increase the average net cost. This, besides, does not include the cost of removal of the dredged material, nor the depreciation, the interest and the insurance.

It should be added, on the other hand, however, that the warm season was far from being favorable to the energy and perseverance necessary to carry on successfully experiments of this kind. The temperature, even at midnight, was often 38° C. (100.4° F.). Still further, the work was constantly interrupted by the passage of ships through the canal. On an average not more than forty minutes' work to the hour was obtained. Notwithstanding this, there were extracted at Chalouf, on an average, 38.225 cubic meters (50 cubic yards) per day without interrupting navigation. At Port Tewfick, where there was much less inconvenience from the passage of ships, the work was carried on from eight to eleven hours per day and the quantity extracted in this time was generally more than 76 cubic meters (99.4 cubic yards).

In most cases the system could be simplified. The engine which works the dredge could, when not thus employed, be used to drive the pumps. The propelling engine could also be used for the same purpose.

The results obtained at Suez indicate the appreciable advantages arising from the application of this system to the works of ports, rivers and canals, and even to the work of cutting in the construction of roads and railroads.

IX.

RAIL JOINTS.

By G. W. Creighton, Active Member of the Club.

Read May 17th, 1890.

Probably no detail of railroad construction has been more fully discussed, investigated and written about, than rail joints. An endless variety of devices have been used in actual practice, the earlier forms, chairs and sleeve chairs, being gradually set aside

as valueless as the weight of rolling stock increased, until at the present time we find but two general classes:

(1) The angle splice joint.

(2) The bridge joint.

The angle splice, used on a very large proportion of the railroads in this country, may be and is used either as a "suspended" joint—the rail ends being intermediate between the two joint ties, and the splice bars extending either way to, and resting upon, the joint ties—or as a "supported" joint—the rail ends resting on a joint tie and the splice bars extending either way to, and resting upon, the two ties adjacent to the joint tie.

Until very recently, say five or six years ago, the former or suspended angle splice joint was the only form in which this device was used, the length of the bars being about twenty-four inches. The large number of broken splices called for an improvement, and the weight or rather section of the bars was increased and some slight changes made in the composition of the metal, with the object of strengthening the splice and rendering it more elastic, or what has been called "softening the metal." This treatment reduced the number of breakages, but not to the extent desired, and the next radical change was increasing the length of the splice to thirty-four inches, using the same form of suspended joint. The particular object in the increased length, with no increase in the section, does not seem clear. Certainly the weakness of the structure is at the joint, and it is rather hard to explain what the increased length of splice was to do toward strengthening the weak section. It has been argued by eminent engineers, and those who have had large practical experience, too, that this increased length would make the rail end more rigid and less likely to deflect at the joint. No doubt that view of the matter is correct, but the increased rigidity is not wanted in the rail except at its *extreme* end. By extreme end we mean that portion which overhangs the joint tie. Let us examine the known strains to which rail joints are subjected. For illustration we have attached several sketches, by reference to which the matter will be more clearly understood.

The forward wheel in a car-truck, just before reaching the joint, presses the rail and tie more or less deeply into the ballast.

The unloaded joint tie acting as a fulcrum, the rail end is thrown upward, the upper fibers of the angle splice bar being subjected to a tensile strain. As the wheel reaches the position shown in Figure 1, resting immediately over the joint, the rail ends are depressed as much as the elasticity of the splice will allow. This results in a compressive strain in the upper fibers of the splice. The wheels next assume the position shown in Figure 2, one wheel either side of the joint, both joint ties acting as fulcrums, throwing both rail ends upward, carrying the angle splices along, producing tensile strain in their upper fibers. Next, Figure 3, the last or rear wheel in the truck depresses the joint, producing compression in the upper fibers, and when this rear wheel passes beyond the joint tie a tensile strain is again apparent, and it continues until the wheel reaches a point so far removed from the joint that the elasticity of the rail prevents the transmission of strain to the splice.

Thus, in a second of time or less, at a speed of fifteen miles per hour, the joint is subjected to five distinct strains, alternately tensile and compressive. Practically, these strains are so rapidly reversed that they should be considered " blows " as upon an anvil, and with the large cars and loads, considering also the speed, an effective force of at least 25,000 pounds is produced. The section of the ordinary angle splice would not be expected to resist such enormous strains so rapidly delivered, in any other railroad structure, and it seems peculiar that some radical increase in section is not made or some new form of splice adopted.

Having outlined in a general way the strains which, to the writer's mind, seem to be the principal ones to which rail joints are subjected, it is well to inquire how an addition of five inches to either end of a splice twenty-four inches long is to increase its strength.

The additional length only increases the leverage, when the joint is loaded, as in Figure 2, with a wheel either side of the splice. Given the same conditions as to roadbed, rail and splice section, the increased rigidity of the rail ends produces a more effective lever in the proportion of seventeen to twelve inches. Under compression, the long splice and consequently increased rigidity of the rail ends no doubt reduce somewhat the compressive strains.

The "supported" form of angle splice joint, varying in length from forty to forty-four inches, has been adopted by various railroads, the opinion being that there are less broken splices than with the shorter "suspended" form. These splices do break, however, as has been demonstrated frequently, and it is a question whether the increased cost more than counterbalances the difference in the number of broken splices.

Bridge joints are of various forms, the general principles being clearly illustrated in the well-known Clark Fisher Joint. The distinctive features are: (1) a supporting plate upon which the rail ends rest, either end of said plate extending to and resting upon the two joint ties; and (2) a device (either bolts or clamp) to hold the rail ends firmly to the supporting plate.

This form is, on well-cared-for railroads, successful in resisting loads vertically, but is lacking in lateral rigidity and has no strength to resist the vertical motion of the rail ends.

Before calling further attention to the defects of these joints, let us consider the requirements of a theoretically perfect rail joint.

Having determined the general character of the rail that is best adapted to the work that it is to be called upon to perform, it is necessary to provide a rail joint that shall

(1) Preserve the "rigidity" of the rail as a continuous beam, making it as "stiff" at the joint as elsewhere.

(2) Preserve the elasticity of the rail, allowing the same flexibility at the joint as at other portions of the rail.

(3) Insure perfect alignment of the rail ends so that the wheel flanges will have unobstructed passage over the joint.

(4) Insure absolute uniformity of surface in the abutting rail ends, so that there will be no "battering" of the same.

(5) Transmit the weight imposed on one rail end through the medium of the splice to the other rail end, so that each shall be equally strained.

(6) Permit the "rail wave," preceding wheels, to traverse the joint uninterruptedly and unbroken.

(7) Permit expansion and contraction of the rails.

Now, considering these numerous requirements of a perfect joint and the variable conditions of roadbed, ballast and traffic, it is readily seen that the task of providing a suitable joint is no

easy one. We can, however, point out the defects in the present form of angle splice and bridge joints.

The original twenty-four-inch angle splice joint was weak vertically, superimposed loads forcing the inclined under-surfaces of the rail heads *through* the splice bars, in time wearing the upper fibers away, allowing " play " between the rail head and splice, causing "rattling" joints. As the wear increased, the incision or abrasion in the splices weakened them so that the alternate compressive and tensile strains produced fractures, thus destroying the joint.

The thirty-four-inch suspended angle splice joint has the same defects as the twenty-four inch splice, the compressive strains, however, being less effective, so far as wearing the upper fibers of the splice bars is concerned. This splice, however, is so long that the progress of the " rail wave " is obstructed, and upon reaching the receiving end of the splice bar the wheel is compelled to "jump over the wrinkle" (to use a homely expression), the result being an unnatural wear upon the rail head at that point. This objection does not obtain, however, in perfect stone ballast where there is practically no rail wave, but on poorly ballasted roads, noticeably in sand and gravel ballast, it holds good. The forty to forty-four-inch supported angle splice joint reduces the number of broken splices, but impedes the progress of the " rail wave " and throws too much stress upon the joint tie, it receiving practically the same loads that are distributed between the two joint ties in the suspended angle splice joint.

The bridge joint in its various forms, while offering advantages with the load immediately on the joint, does not preserve uniform alignment of the rails, and under repeated blows the corners of the flanges of the rail ends are broken off, rendering the joint absolutely useless, as this form of joint depends wholly upon the grip obtained upon the rail flanges. It may answer on perfect roadbeds, the New York Elevated Railroads, for example, but elsewhere it is a failure.

The rail ends are not so secured as to transmit the " rail wave " from rail to rail, neither is the load carried partially by each rail end. The loaded wheel strains but one rail, its flange or base transmitting the entire load through the supporting plate to the

two joint ties. Immediately on reaching the next rail the load is borne entirely by that rail, and, through its flange and the supporting plate, carried to the joint ties. Thus each rail acts as a separate and distinct girder instead of the "continuous" girder, which is a distinctive feature of perfect track.

With this general review of the subject and criticisms of the present forms of rail joints, it may not be amiss to offer a suggested improvement in the device, that, in the writer's opinion has some merit.

As a rule, new track is laid as follows:

The roadbed having been properly graded, the cross-ties are spaced and lined approximately, the rails then laid upon them loosely, allowing, by the use of shims, the proper openings for expansion and contraction. Thus far we have followed the usual practice, but here let us change the order of work, and, before "splicing" the rail, spike it carefully to the cross-ties, preserving the proper joint openings. We now have unballasted track without splices. Now, the form of the splice suggests itself to the mind. Why use a splice that shall rest upon the joint ties, imposing unnatural duty upon those ties when all other parts of the rail bear directly upon the ties, imposing upon them only the load carried by the rail? Looking at the matter in this light is what suggested the form of splice proposed, that shown in Figure 4.

The peculiar features of this rail joint are:

(1) The double section of the ordinary angle splice bar.

(2) The splice rail, the same length as the splice bars (an I beam will answer as well, as shown by dotted lines in the sketch).

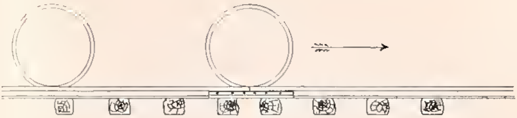
The novel features are not the use of the deep section of splice bars or the use of a splice rail, for they are both old, as is well known, but the claim is that the peculiar shape of the bar, and the manner in which the upper and lower edges engage with the under sides of the main and splice rails, the double lateral flanges at the same time gripping the two rail flanges securely together, constitute an entirely new idea in rail joints. By an examination of the section of the joint it will be seen that the tightening of the bolts wedges the rail bases together so that there is absolutely rigid contact at all times. The load upon the joint tends

to depress the rail ends; but the flat, inverted rail base below prevents any movement whatever, unless an extraordinary pressure should tear the bars apart lengthwise through the curved edge connecting the upper and lower lateral flanges. Such a strain will never be imposed on the joint. The length of the joint (twelve inches) permits its insertion between the joint ties without spacing them too far apart to affect the uniformity in the spaces on the opposite rail. The load imposed directly on the joint does not deflect or depress the rail ends, hence the splice bars have little tendency to separate, and if the bolts are moderately tight the load is transferred not only through the web of the rails but also through the vertical flanges of the splice bars. The stresses then tend to force the inverted base of the splice rail through the lower sections of the bars. In order to do this, however, the bearing of the vertical flanges of the bars upon the inverted head of the splice rail must be destroyed. This cannot be done unless the bolts are torn apart or broken. Strains that will accomplish this cannot be produced with any load that can be placed on so short a span.

The strains have now reached the head of the splice rail, tending to shear it off. This strain acts in tension on the web of the splice rail and is transmitted to the splice rail flange or base, finally resulting in a tensile strain along the entire curved edge of the splice bars connecting the lower and upper lateral flanges of the same.

The pull is uniform from end to end of the bars; hence, with flanges one-half inch thick, we would have a twelve-inch section (or rather two six-inch sections) to disrupt before the splice will fail.

The splice will certainly bear without distortion the greatest possible vertical loads, and when the joint is loaded, as in Figure 2, with a wheel either side of it tending to throw the rail ends up, the flexibility of the rail (only six inches of its end being spliced) will produce little tension in the upper fibers of the splice bars, and the short length of the bars and their extreme depth are other elements of strength. So there is scarcely a possibility of a break occurring, as is usual with the ordinary angle bar. Placed between the cross-ties and in such a position as to bear against their sides,



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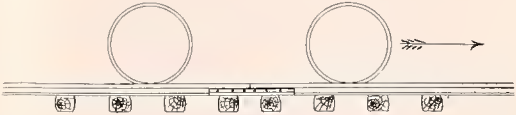

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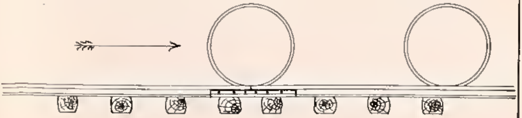

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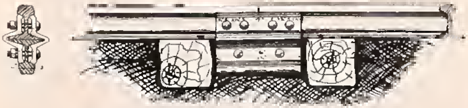

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the creeping of the rails is prevented unless the cross-tie is forced bodily through the ballast. The "rail wave" is less likely to be affected by a splice of this length, particularly as the splice simply fastens the rail ends together and does not rest upon the joint ties. Absolutely perfect alignment of the rail ends is secured, the continuous splice rail gripped by the splice bars holds the rail ends firmly in a straight line.

An objection may be made to the joint that it does not allow dirt or foreign substances, that may work into the rail opening, to drop through to the ground. Neither is there any such provision in any supported joint, and yet we never hear of rails being thrown out of gauge by expansion due to clogged joint openings. In such cases it is invariably the fault of trackmen allowing too little expansion space when rails are laid.

This proposed rail joint has not been put to a practical test, and it is therefore impossible to do other than theorize on its merits. The object in suggesting the joint is to stimulate ideas and discussion, and although, as stated previously, the subject has been fully ventilated and discussed by eminent practical men in the profession, yet it is felt that with the march of progress observed in railroad practice every day, there should be a corresponding advance in the matter of rail joints.

X.

GRANOLITHIC PAVEMENTS.

By Robert A. Cummings, Active Member of the Club.

Read June 21st, 1890.

While the somewhat hackneyed subject of street pavement and paving material has consumed so much attention of late, but little has been said of a material for a sidewalk. From this cause the present paper has been hastily prepared, to draw your attention to the granolithic pavement, which possesses many virtues, at least as far as hygienic considerations, general comfort, convenience and durability are concerned.

Granolithic pavement is a patented pavement of large separate blocks. It has a solid foundation of well-broken stone or slag, thoroughly rammed to twelve inches deep, on top of which is laid the pavement proper. The first course consists of concrete laid about four inches thick, in proportion (by measure) of one part of the best English Portland cement to three parts of clean sharp sand and six parts of broken stone that will pass through a two-inch ring; the whole is then well mixed, and water added until it forms a stiff, pasty mass. Having placed this concrete, it is well rammed with ordinary street rammers, weighing from 35 to 40 pounds each, after which the final and finishing course is applied, which is about $1\frac{1}{2}$ inches in thickness, and consists of one part of Dyckerhoff's cement, thoroughly incorporated, while dry, with two parts of crushed granite and the desirable quantity of lamp-black for coloring, the crushed granite having been passed through a sieve with one-half inch meshes; this is then made into paste by mixing well with the requisite quantity of water, which varies somewhat according to the time of year and climate in which it is being laid. This variableness is a necessity for finishing purposes, more especially so when exposed to the hot rays of the sun in summer, and, on the other hand, the necessity for quick setting in winter. Having then laid the final course, an even surface is made with ordinary plasterer's "floats," and, while it is still "green," the whole pavement is rolled with a brass roller so shaped that the surface becomes speckled with small indentations, and left in this state until sufficiently hard for travel.

European Practice.—In Europe it is quite common to place one-quarter inch soft wood strips between each two stones, to take up the contractions and expansions caused by a changeable temperature.

Cross-section.—The attached sketch shows a cross-section of granolithic pavement as adopted and laid by the Norfolk & Western Railroad Company for the platforms and station grounds of Lynchburg passenger station, where over 23,000 square feet are laid, and giving fair satisfaction. The ease with which this can be cleaned, its durability, and its low cost of maintenance, are among the more prominent features which especially recommend

it for such purposes. However, aside from this, Mr. Rudolph Hering, M. Am. S. C. E., in a paper read before this Club* in March, 1882, says that the resistance to traction of a level granite tramway is $\frac{1}{166}$ of the weight of the load. This may be taken, without much degree of error, to represent the resistance to traction of granolithic pavement. From this it would appear that such a material is very desirable where heavy baggage trucks, etc., are constantly being moved.

The adaptation of granolithic pavement is obviously a theme that requires attention, for where it is subjected to appreciable strains, it becomes necessary to take exceptional precautions in order to prevent undue cross-strains and a disturbance of the foundations; *e. g.*, in the grounds of a railway station, where the cross-ties abut against the edge of the platform, a vibrating and sympathetic motion is produced from the passage of heavy trains, which, in due course, is partly taken up by the monolithic pavement. A notable illustration of this has been brought to the writer's notice, where a continuous platform was laid of granolithic pavement, about 600 feet long, especially strengthened along the curb, and about equally divided into widths of 40 feet, 20 feet and 10 feet, respectively. In the two former portions, it is sound and all that can be desired; in the latter, where the mass is small, 70 lineal feet crosses a very substantial plate girder bridge; this portion was purposely divided into stones of five feet sides, to admit of an elastic movement from the deflections of the bridge; it has now become apparent that this resilient effect is by no means favorable to the life of the granolithic. From the former of these strains, the pavement at each end of the bridge is cracked transversely; and there is a considerable longitudinal crack some distance from the bridge, caused, no doubt, by the disturbance of the foundation through the passage of fast and heavy trains. However, had this portion been of minimum width of 20 feet, these strains would have been absorbed by the increase of mass. Hence, from the above it is to be inferred that granolithic pavement should not be applied under these conditions, unless it is thoroughly supported. For street sidewalks and footways it is a

*Proceedings Engineers' Club of Philadelphia, Vol. III, No. 2, June, 1882.

most desirable paving material, especially so in cities, where it is essential to have an even and flush surface. No stop-cocks for gas and water supply, no hinges of basement lights and gratings, should be permitted to mar the entire advantages here specified.

These nuisances and others noted by Prof. Haupt, in a paper read before the Franklin Institute, in December, 1889, on "Municipal Engineering," from which the following is an extract, will tend to impress the necessity for an improvement in the present state of things: "A long-suffering community seem to regard the use of the sidewalk for storing and displaying goods or empty boxes as either a privilege or a necessity, and prefer to take to the roadway rather than wait until a dray-load of cotton, etc., can be discharged by skids into the front doors of the stores or warehouses. While the majority of our streets are sixty feet wide, giving thirty-four for roadway and thirteen on each side for pedestrians, nearly half, and in many places, more than half, of this is obstructed by projecting steps, signs, show-cases, trees, fire-plugs, telegraph poles, lamps, carriage blocks, hitching posts, news and fruit stands, and an occasional pump, to say nothing of the contents of the stores, which are exposed for sale daily on the pavements.

"It may, therefore, appear to be a restriction of personal freedom to learn that in London trucks and wagons are not allowed to back up against the curb and to place a plank across the pavement; packing-cases and barrels are prohibited under the strictest police regulations from being placed on the sidewalk. Neither is it permitted to dump coal, unload barrels or any articles whatever upon the streets between 9 A.M. and 6 P.M., but all merchandise is required to be handled directly by cranes attached to the buildings or warehouses and reaching to drays in the streets or in bags and baskets. Thus the latter are preserved for legitimate purpose of transit."

The following is a table showing tensile tests per square inch of English Portland cement and crushed granite used in granolithic work:

TESTS OF CEMENT AND GRANITE DUST.

Briquettes of Am. Soc. C. E. Standard Shape.

No. of Test.	Date made.	Length of Time Setting.		Age in Days.	Composition in Volumes.		Tension in Pounds per sq. in.		Date broken.	Time occupied in breaking.	
		In Air.	In Water.		Cement.	Granite Dust.	Each Block.	Average of two Blocks.		Each Block.	Average of two Blocks.
		Hours.	Hours.								
160	Apr. 3	1	23	1	neat.	....	130, 124	127	April 4	....	.....
161	" 3	1½	46½	2	neat.	....	150, 130	140	" 5	....	......
162	" 3	4¾	163¼	7	1	2	124, 126	125	" 10	....	......
168	" 4	8	712	30	1	2	236, 279	257½	June 4	40 sec., 45 "	42½ sec.
170	" 4	6½	713½	30	neat.	....	528, 450	489	" 4	90 sec., 70 "	80 sec.
171	" 5	1½	166½	7	neat.	....	370, 350	360	April 5	....	......

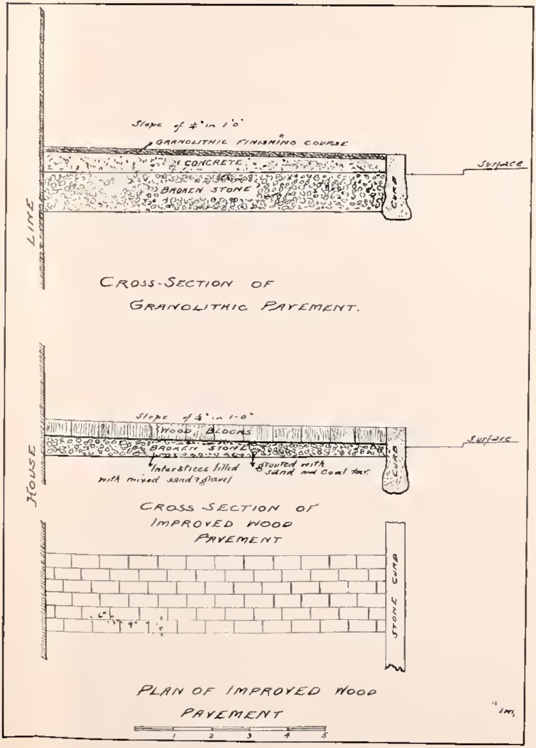
The superiority of a granolithic pavement may be briefly summarized: (1) there are but very few joints to collect filth; (2) from its durability and toughness it produces no dust; (3) it is impermeable to moisture, etc., hence prevents the emission or transmission of unhealthy vapors; (4) it is easily cleaned.

An objection, however, has been raised that it is too solid, and not sufficiently elastic for continual walking, and that pedestrians who suffer from the ill effects of flag-stones and brick pavements (to say nothing of the effect upon one's morality from treacherous loose bricks and mud) require a paving material that is more elastic, more comfortable and less costly. With this in view, the following has been designed to combine as many advantages of paving material as possible. It is simple and inexpensive, and the accompanying sketch shows the comparison of such a pavement with granolithic. The first course is five inches thick and of broken stone, the interstices being partly filled with a sandy gravel, thoroughly rammed to an even surface; this is then grouted with a mixture of sand and coal tar until the whole surface is covered, which is virtually the next course. The wearing material is white cedar wood, in blocks 4 x 5 x 9 inches, breaking joints as shown in sketch.

The blocks are pressed into the superfluous grouting material, a portion being squeezed up between them, and any open joints that appear on the surface are to be filled, thus forming virtually a continuous unbroken surface. The advantages of this pavement are, briefly: (1) its low first cost; (2) its elasticity; (3) its durability; (4) its low cost of maintenance; (5) its general comfort and convenience; (6) its hygienic qualities; (7) the ease with which it can be cleaned; (8) its impermeability to moisture from below.

The above specifications are not intended as final, and will admit of much variation in detail.

An eminent writer has said that "The road is that physical sign or symbol by which you will best understand any age or people. If they have no roads they are savages, for the road is the creation of man and the type of civilized society."



CROSS-SECTION OF GRANOLITHIC PAVEMENT.

CROSS SECTION OF IMPROVED WOOD PAVEMENT

PLAN OF IMPROVED WOOD PAVEMENT

XI.

TOPOGRAPHICAL SURVEYING.

By Harvey Linton, Active Member of the Club.

Read November 1st, 1890.

The usual method of making preliminary surveys is generally accepted as the only practicable one. This requires a field party of ten to sixteen men, a chain, a line of stakes, with transit, level and topographical notes to be intrepreted and plotted in the office.

If all this work is well done the result is satisfactory; therefore, other methods for accomplishing the same result are seldom considered. The use of stadia wires in a transit telescope for measurement of distances, and the adaptation of the transit instrument, together with some form of plane-table for field plotting, are certainly practicable; the results are accurate, and the economy of time and money, in comparison with the requirements for surveying with chain measurements, is very considerable.

Mr. Rudolph Hering, active member of this Club, when in charge of surveys for the proposed new water supply for Philadelphia, in 1883–6, adopted the system of stadia measurements, and the plotting of maps in the field.

For the latter purpose a light plane-table, about fifteen inches square, was carried by the surveyor, who, with one rod-man, comprised a field party.

The magnetic needle was relied on for the bearings of lines, which were run in circuits of one to three miles.

Frequent connections were made with points established by a system of triangulation. This system is an extension of that of the U. S. Coast and Geodetic Survey.

Numerous bench marks, with their elevations above tide level marked upon them, were established in advance of the topographical survey.

One square mile per day in open country was occasionally surveyed and plotted in the field by one party, the scale of the map being one inch to 400 feet, with contours showing ten feet difference in elevation.

One-half a square mile per day was a good average, in rolling, partly wooded country, points being observed in sufficient number to insure a correct map. Not much reliance was placed in mere sketching.

The details on the field sheets were clearly defined by drawing them with differently colored crayon pencils—blue for streams, green for woodland, sienna for roads, and red and yellow for brick and frame buildings respectively.

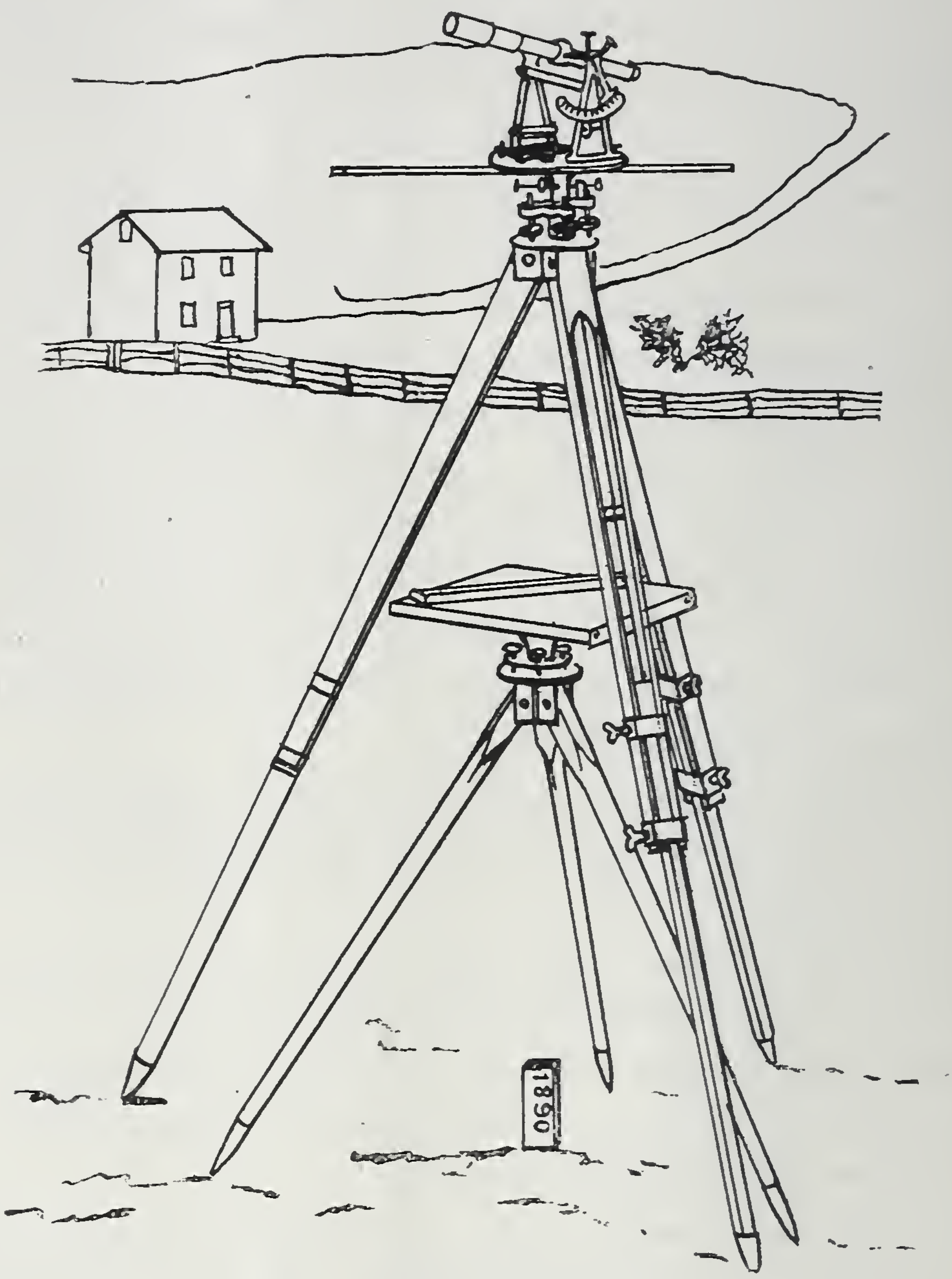


FIG. 1.

In connection with this work, the writer first measured the azimuth angles of a stadia survey (for making a water conduit location), by means of two transit instruments.

He has also lately used a small plane-table and a reflecting

rule, which, in connection with the transit instrument, greatly facilitate the plotting of topography in the field. These modifications of this system of rapid surveying make it well adapted for surveys of railroad routes and also for mapping large tracts of land, as mining properties, etc., where the magnetic needle cannot be depended on for bearings of lines.

A map so plotted on the ground will make unnecessary the preservation of a variety of field notes.

A record should be kept descriptive of the principal line of the survey.

The objection that stakes are not set at every one hundred feet, and that therefore the location of the survey is too indefinite, is not a serious one. Not only are stations that have been occupied by the instruments definitely marked on the ground, but one or more corners of every building near the line may, and should be, located and their elevations noted. Other prominent features, as fences, bridges, isolated trees, etc., make good reference points for a projected location.

If the work is well done, and contours correctly drawn, the first line of stakes necessary will be those used in making the final location.

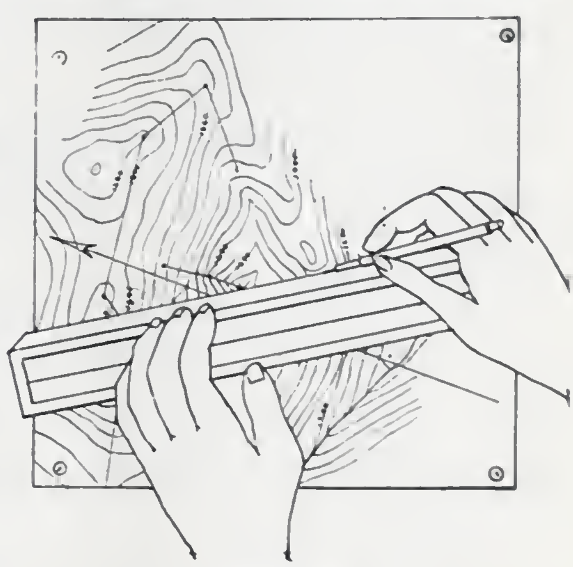


Fig. 2.

In conducting surveys for railroad lines, and wherever the location of points by triangulation is not practicable, the field party may be organized as follows: The chief and his assistant, having each an engineer's transit, with level and vertical-arc attachments, and stadia wires in the telescope, two rod-men, each with a self-reading rod and a light plane-table, twelve inches square, that will stand about three feet from the ground, and two ax-men, complete the party. These ax-men should assist as rod-men in open country.

The plane-tables are set up under the transit instruments, after the latter have been centered over their respective stations.

Sheets of drawing paper, about 12 inches by 14 inches, are used, one sheet at each station.

Having stationed his assistant at the point of beginning (sta-

tion 0), the chief will proceed to the next station (1), where he will set up his instrument and plane-table. One rod-man and one ax-man will accompany him.

The observer at each station will record the distance between stations 0 and 1, and also the vertical angle and the magnetic bearing. This being done between all the stations of the survey, no great error is likely to occur.

After plotting all the details required that can be seen from his station, the assistant, with his rod-man and ax-man, will proceed to the next turning-point in advance, or station 2.

With the vernier of the instrument at station 1 reading 180 degrees, when the telescope is set on station 0, it will show the deflection of the line at station 1, when the telescope is set on station 2. In this manner the azimuth angle at every station will be observed and will be recorded, together with the bearings of the magnetic needle, as a check on the computed bearings.

Instead of reading the deflection angle from 0° at each station, the vernier of each instrument may be made to show the computed bearings.

Having fastened the paper on the plane-table and set it level, a fine needle is fixed vertically thereon under the center of the transit.

It is required to plot upon the plane-table sheet the direction and length of each line of observation from the transit instrument, together with the meridian, the contours and a correct representation of streams, roads, buildings, etc., in the area to be surveyed.

A straight edge, about twelve inches in length, being provided, with the scale of the map on its edge, a plane-mirror is fixed on the upper side, the plane of the mirror being parallel with the surface of the plane-table when lying upon it. In the center of this mirror, and parallel with the straight edge, is a fine, straight line. Attached to the transit instrument, and projecting six or eight inches on each side of the plate, is a straight edge, or sights similar to those used on a surveyor's compass, set, for convenience, parallel or nearly so with the vertical plane of the telescope.

This straight edge, slotted sight or fine wire, is fixed to the vernier plate, and its position is constant with relation to the vertical plane in which the telescope moves.

The reflection of the sights in the mirror being made to coincide with the fine, straight line on the surface of the mirror, the line drawn upon the plane-table sheet, from the needle center, before described, along the straight edge, will represent the line of sight from the telescope. Thus, every sight taken with the telescope can be quickly and correctly drawn upon the plane-table sheet.

A connected map of the survey may be made by transferring the lines and topography from the field sheets to larger sheets or rolls in the office; first, establishing meridians on these sheets or rolls, and then making the meridians of the field sheets parallel therewith; or, the line of the survey may be plotted in the office, and the topography from the field sheets be afterward transferred to the office map. Tracing-paper, blackened on one side by Dixon's graphite "Timber" pencils, makes a satisfactory transfer paper.

The accompanying photographs show the plane-table and transit instrument in position for use, and the straight edge and scale with the mirror attachment.

NOTE.—With a field party of six men in all, and instruments, etc., as described, it is possible by the above-described method to survey and plot one square mile of territory in open country, to scale of one inch to 400 feet, and ten-feet contours, accurately enough to project a railroad location on any part; or, four miles in length of preliminary line, showing all necessary details of topography for an average width of one-quarter of a mile, in one day.

Making allowance for bad weather, twenty square miles per month for nine months of the year, or 180 square miles in all, can be surveyed and plotted on the field sheets in a year; equivalent to 80 miles per month (or 720 miles in a year, allowing for bad weather) of preliminary line and topography, plotted for an average width of one-quarter of a mile.

Plotting the topography without so much accuracy of detail, to scale of one inch to 800 feet, with ten-feet contours, 25 square miles per month can be surveyed and plotted.

With twenty-feet contours to scale of one inch to 1,600 feet, 33 square miles per month can be surveyed and plotted.

In a country thickly covered with forests or brushwood, and having but few roads or none, the work accomplished might be 50 to 75 per cent. less than the above estimate.

Following are the instruments required :—

Two transit instruments and attachments........	$520 00
Two plane-tables and alidades..	120 00
Four vernier telemeters (Craig's)..	60 00
One office drawing-table...	20 00
Total...	$720 00

Estimate of cost of a topographical survey for one year, including completed office map.

Interest, depreciation and repairs of instruments, valued at $720.00, at twenty per cent	$144 00	
Traveling expenses and incidentals	500 00	
Drawing paper and stationery	150 00	
Office rent for three months, including heating, etc	60 00	
		$854 00
Salary of chief engineer	$2,400 00	
Salary of assistant engineer	1,500 00	
Salary of rod-man	600 00	
Wages of junior rod-man and two ax-men	1,170 00	5,670 00
Total annual expense		$6,524 00

Equivalent to $27.18 per square mile, or $4\frac{1}{4}$ cents per acre, for map to scale of one inch = 400 feet, 10-feet contours.

" " $21.75 per square mile, or $3\frac{4}{10}$ cents per acre, for map to scale of one inch = 800 feet, 10-feet contours.

" " $18.12 per square mile, or $2\frac{83}{100}$ cents per acre, for map to scale of one inch = 1,600 feet, 20-feet contours.

Camping outfit, long distance transportation, and special supplies for unsettled country must be estimated for in addition to the above, if necessary.

XII.

CONTINUOUS RAILS FOR RAILWAYS.

By R. Taylor Gleaves, Active Member of the Club.

Read November 15th, 1890.

It must be a mistake that "there is nothing new under the sun." I am perfectly willing to believe the assertion that the Chaldeans and the inhabitants of "Al Kris the Magnificent" had telephones, phonographs, and wonderful electrical apparatus. For all that is known to the contrary, Mr. Alladin may have had a lamp that in some particulars was superior to the "Rochesters" of to-day. Doubtless Mr. Sinbad was superior as a navigator to Mr. Hendrik Hudson, but it is a certainty that none of these gentry ever rode upon a railway laid with continuous

steel rails, and that is what a few people are to-day doing in Virginia.

In 1886, Philip Noonan, a section master on a Louisiana railway, took out a patent on a "self-surfacing track," the chief feature of which is a continuous rail. Owing to the lack of means and influence, he was unable to thoroughly test the patent until June, 1889, when I laid three miles of track, under that system, on the Lynchburg and Durham Railroad, and now, after a test of seventeen months, I venture this account of it.

The ground covered by the patent may be briefly stated as follows: Continuous rails of the ordinary T pattern, carried upon ordinary ties of wood or iron weighted down with a covering of earth, gravel or stone, so that they cannot easily move.

The spikes are not driven home, by three-eighths of an inch, so that undulations may take place in the rail without disturbing either the spikes or ties. At fixed points in the track, such as frogs, and at the foot of heavy grades, the main line rails are turned out with an ordinary split-switch point, as if a regular turnout was to be put in.

In Fig. 1, A is the switch point that continues the gauge of main line; B is the main line rail turned out; C is a cast-steel clutch, one end of which grips the base of the rail, the

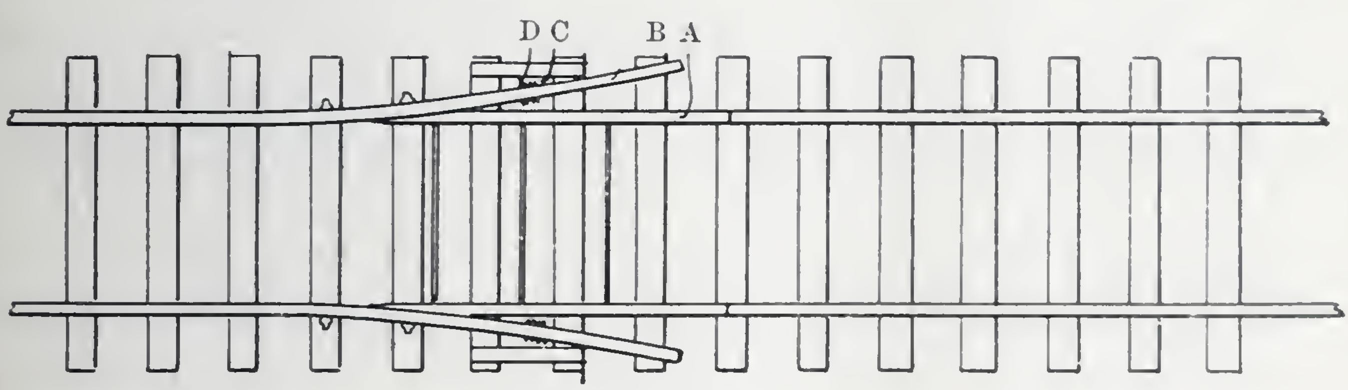


Fig. 1.

other bears against the 10-ton spiral spring D. The action of the track is as follows: Owing to the spikes being slightly lifted, the rail has a limited vertical motion, and owing to the turnouts at each end of long sections, a free longitudinal motion. Now, when a rolling load comes upon it, minute waves are formed, and the rail creeps in the direction the load is moving. You are all familiar with the annoying results brought about by this in the or-

dinary track, but under the Noonan system it becomes the *summum bonum* and brings out the striking features of the patent. The action of the track under a moving load resembles that of a linen collar when a laundryman passes a flat-iron over it; the undulations formed in front of the iron (or load) are pushed ahead to the end of the collar (or track section), leaving all behind it straight and smooth; and in the case of the rail the clutch C allows the waves to pass out, and the spring D takes up any backward motion of the rail and prevents noise or jar. Fig. 2 is a section of the track, showing the lifted spikes and the covering of the ties. In putting down the track, the first difficulty encountered

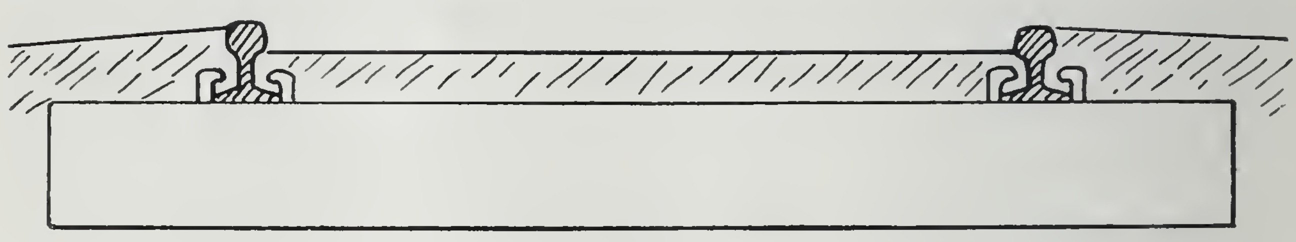


Fig. 2.

was to secure an absolutely continuous rail. The cost of an electric welding plant placed it beyond my reach, and I was, therefore, forced to use two heavy fish-bars, $\frac{3}{4}$-inch thick, bored with round holes, that corresponded to the fishing of the rails when the ends were brought in contact; then with drift-pins and four one-inch rivets I made a joint that has not opened in the slightest, and a rail that is practically continuous. While the riveting was in progress, and before the track had been either surfaced, lined or covered, there was some trouble from expansion; but since it has been completed there has not been the slightest buckling, nor is there any perceptible pulling in on the curves.

The ties are covered with a red clay containing some loam, and to prevent dust I turfed a part of the track and sowed grass-seed over the remainder. Now, instead of a wrench, the watchman pushes a mower, and the roadbed looks like a pretty green lawn with two metal ribbons laid across it. It is useless to call your attention to the expansion of an ordinary thirty-foot rail under the various ranges of temperature, but I am much puzzled to tell what becomes of the expansion and contraction in a rail three miles long *when it is at rest.* So long as rolling loads are passing over it, and the rail has a longitudinal motion given it every few

hours, I can easily account for the disposition of changes in length; but these rails have remained undisturbed for thirty-six consecutive hours during a variation in temperature of thirty degrees, yet the alignment of the long tangents has not varied, nor have the curves altered their positions. I am well aware of prejudice against new appliances, and I, myself, confess to a conservatism that makes me dread the advent of a man with a patent. In the case of this track system I declined positively to test it until directed to do so by the President; but now that the test is made, I am a convert, and, with the zeal common to recruits, must speak out.

Quite a number of trackmen and a few engineers have examined the system. The trackmen are all delighted with it; the engineers look wise, shake their heads, and doubt its utility.

One prominent manager listened very intently to a description of it and then said: "Why, it's impossible. No track can be maintained without stone ballast and constant labor."

It is natural that I should dislike being doubted, yet my convictions force me to the following assertions: that there is in Virginia a section of track laid with rails three miles long; that it has been in service since June, 1889; that it has not been surfaced or lined since put down; that the only expense of maintaining it has been the watchman; that engines weighing 104,000 lbs. are frequently run over it at a speed of 50 miles per hour, that it is simply ballasted with earth, and that I shall take pleasure in showing it to any one who cares to investigate.

XIII.

THE ABNORMAL RAINFALL OF 1889.

By John E. Codman, Active Member of the Club.

Read December 6th, 1890.

The remarkable meteorological conditions during the year 1889, extending as they did over a large portion of the United States, make a study of the recorded observations an interesting

subject, of much more general importance than the object or intention of this paper is prepared to meet. This paper will be confined mainly to local and personal observations, the instrument used, and the methods employed in obtaining and recording the data. The principal subjects observed are: 1st, the rainfall or total precipitation; 2d, the humidity; 3d, the temperature; 4th, the effect of these, combined, upon the amount of water draining away in the natural water channels. The results constitute a valuable and reliable collection of information.

The Philadelphia Department of Public Works maintains six stations at which rainfall observations only are taken, and three stations at which both stream-flow and rainfall records are kept. Three of the rain gauges are automatic, recording the beginning, ending, length of time, rate per hour, and the total amount of rainfall for each 24 hours.

These gauges are placed in small buildings about six feet square, specially constructed for this purpose. The collecting funnel is $22\frac{5}{8}$ inches in diameter, placed upon the roof of the building, a small lead pipe leading down to the recording device. This consists of a bucket suspended by very light spiral springs, into which the water drops, causing the bucket to descend until it has elongated the springs exactly five inches, when it will tip over and spill the water out, and is then drawn up again by the springs. Each time the bucket dumps, it records 0.05 of an inch of rain. The bucket has attached to it a pencil which traces a line on a prepared sheet of paper ruled with vertical and horizontal lines. The horizontal lines represent hundredths of inches, and the vertical lines represent hours. The paper is moved along by clockwork and will run for 48 hours. On reaching the end of the paper, if no rain has been recorded at any hour since the paper was placed in position, it is moved back to the beginning. All the sheets with rain records on them are taken off at the end of 48 hours. When the rain falls very fast the vertical lines traced by the pencil often run together, so that it becomes impossible to count them. To meet this difficulty, a copper cylinder having one-tenth of the area of the collector is placed beneath the dumping bucket. Into this cylinder all the water falls, and the amount is measured at the end of every storm, as in an ordi-

nary gauge, and is compared with the amount recorded upon the sheet. If the lines at any part of the storm are so close together that it is not possible to count them, all lines outside of that part are counted, and the result deducted from the total amount measured in the copper cylinder. In this way the amount falling during any part of the storm is found.

During a heavy rain-storm of several hours' duration, the observer will often take a measurement in the cylinder immediately after a sudden downpour of rain, and record the amount in pencil on the sheet at that time. One of these automatic gauges is placed at the Forks of the Neshaminy, one at Frederic, on the Perkiomen, and one at Thirty-second and Spruce Streets, Philadelphia.

During the year 1889 the gauge at Thirty-second and Spruce Streets recorded eight different storms in which the rainfall reached the rate of one inch per hour and over for a portion of the storm. August 14th and 15th, a series of showers occurred, recording a total fall of 2.46 inches in five hours. At one part of the storm one inch fell in twenty minutes, or at the rate of three inches per hour. Twice during the year a rainfall of one inch in twenty minutes, or at the rate of three inches per hour, was recorded. The greatest amount recorded in any one storm during the year was on July 31st, when 2.97 inches of rain fell in 24 hours. The precipitation recorded by the automatic gauge at Philadelphia is compared with the observations taken at the Signal Service, Pennsylvania Hospital, one at Germantown, and three in the Water Bureau. The collectors of the gauges in the Water Bureau are of the following diameters: one of 2 inches, one of 7¼ inches, one of 8 inches, located at Thirty-second and Spruce Streets. The Signal Service collector is 8 inches in diameter, and the one at Germantown is 8 inches. Three of the gauges at Thirty-second and Spruce are 17 feet above the ground, and one 20 inches. Those at Germantown and at the Pennsylvania Hospital are both about 18 inches above the ground. The Signal Service gauge is located on the top of the Post Office building, 165 feet above the pavement. Observations on all these gauges are made daily, as near 8 A.M. as possible. For measuring snow, a piece of brass pipe, 2 inches in diameter and about 36 inches long,

closed at the bottom and the top, and turned to a sharp edge, is placed upright on the open lot. The snow is caught in this and then melted into water and recorded as so much rainfall.

The record of the total precipitation at Philadelphia for the year 1889 was as follows:

By the $22\frac{5}{8}$-inch automatic collector, 17 feet above the ground, and 66 feet above sea-level (U. S. Coast Survey datum),	50.62 inches.
By the $7\frac{1}{4}$-inch collector, total amount,	51.008 "
By the 2-inch collector, " "	50.003 "

The total recorded at the U. S. Signal Office, Ninth and Chestnut Streets, elevation above the ground 165 feet, was 50.60 inches.

The total amount collected at the Pennsylvania Hospital was 60.58 inches, or 9.96 inches more than was collected at Thirty-second and Spruce Streets, and 9.98 inches more than at the Signal Service. The hospital gauge is placed upon the ground, and this may account for a portion of the discrepancy. The gauge at Germantown collected 59.48 inches, or 8.86 inches more than the Signal Service. At Thirty-second and Spruce Streets, for the last ten months, a gauge has been placed with the edge of the collector 20 inches above the surface of the ground. Observations will be continued during the coming season, and the results compared with others where the collector was 17 feet above the ground. So far, the ground gauge has recorded about ten per cent. more than the others.

The amount of rainfall at stations outside of the city, for 1889, varied from 15 to 45 per cent. more than was recorded in the city, West Chester having the largest fall, 73 inches, Pottstown with 71.22, and Ottsville with 71.09, or about six feet of water. The storm of May 30th and 31st, which caused so much loss of life and property in the middle counties of the State, did not extend to Philadelphia. The average rainfall at Philadelphia, by the Pennsylvania Hospital reports, was 35 per cent., or 15.74 inches above the average for the past 65 years. The rainfall of 1889, according to the U. S. Signal Service, where observations have been carried on for eighteen years, was 21 per cent., or 9.85 inches, above the average. The rainfall for the eastern counties of Pennsylvania for 1889 was about 25 per cent. above the average.

The distribution of rainfall throughout the year was remarkable, as it was almost the reverse of the usual order for this latitude. The months of January, February, March, April and December show a deficiency in the average precipitation. The months of May, June, July, August, September, October and November show an excess in the average precipitation. The relative humidity was high throughout the entire year, with low temperature during the warm summer months and high temperature during the winter months, excessive precipitation in the warm months, and a deficiency in the winter months. The total rainfall on the watershed of the Perkiomen Creek, covering an area of 152 square miles, from the average observation of several stations, was 64.24 inches, of which 36.7 inches, or more than half the total, fell during the months of June, July, September and October. The total precipitation on the watershed of the Neshaminy, covering an area of 139 square miles, from the average of several stations, was 64.57 inches. The total precipitation on the watershed of the Tohickon, covering an area of 102.2 square miles, was 68.66 inches. The relative humidity and temperature of the air on these watersheds maintained about the same relations as that given for Philadelphia. On the Perkiomen, Neshaminy and Tohickon streams, automatic stream gauges are placed to register the rise and fall of the water, and from these records the amount of water flowing away at these points is calculated.

During the year 1889 the *flow* of the Perkiomen was 22 per cent. above the average of the five previous years, and the rainfall 23 per cent. above the average for the same period. The flow of the Neshaminy for 1889 was 28 per cent. above the average flow of six years, and the rainfall was 23 per cent. above the average. The flow of the Tohickon for 1889 was 20 per cent. above the average, and the rainfall 24 per cent.

The amount of water flowing away for the year, for the Perkiomen, was 51 per cent. of the total rainfall, Neshaminy 52 per cent., and the Tohickon 58 per cent.

The excessive humidity and the presence of clouds prevented rapid evaporation, and the effect of the above condition is found in the greatly increased amount of water found flowing off from

the surface of the ground, causing heavy freshets in all the natural water courses. The percentage of rainfall flowing off in the stream for the year was slightly above the average for the five previous years. The observations seem to show that the greatest percentage of rainfall flowing away does not follow the greatest rainfall.

The following tables of monthly percentages, when compared with the monthly rainfall, show the variation in 1889 from preceding years:

TABLE SHOWING PROPORTION OF RAINFALL DISCHARGED BY EACH STREAM (FROM OCT. TO OCT.).

Years.	Rainfall.			Discharge in Inches of Rainfall.			Percentage of Rainfall Discharged.		
	Perkiomen.	Neshaminy.	Tohickon.	Perkiomen.	Neshaminy.	Tohickon.	Perkiomen.	Neshaminy.	Tohickon.
Oct., 1883, to Oct., 1884.	48.00	48.84	50.08	32.06	28.32	35.06	66	58	70
Oct., 1884, to Oct., 1885.	38.12	38.28	41.21	18.68	17.61	22.25	49	46	54
Oct., 1885, to Oct., 1886.	47.78	50.24	50.40	25.32	25.12	32.76	53	50	65
Oct., 1886, to Oct., 1887.	50 16	51.89	51.90	21.57	21.27	25.43	43	41	49
Oct., 1887, to Oct., 1888.	50.31	48.77	53 15	26.34	25.43	35 36	52	52	66
Oct., 1888, to Oct., 1889.	60 20	60.54	64.66	30.70	31.48	37.50	51	52	58
Oct., 1889, to Oct., 1890.	56.17	52.95	56.99	32.58	25.95	32.49	58	49	57
	Greatest Rainfall.			Greatest Discharge.			Greatest Percentage Discharged.		
Year, ...	1889.	1889.	1889.	1889.	1889.	1889.	1890.	1888.	1888.
Amount, ...	60.20	60.54	64.44	32.58	31.48	37.50	58	52	66
	Least Rainfall.			Least Discharge.			Least Percentage.		
Year, ...	1885.	1885.	1885.	1885.	1885.	1885.	1887.	1887.	1887.
Amount, ...	38.12	38.28	41.21	18.68	17.61	22.25	43	41	49

TABLE SHOWING PERCENTAGE OF RAINFALL FLOWING AWAY.

	Year.	Jan.	Feb.	Mar.	Apr.	May.	Jun.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
PERKIOMEN.	1883.										27	47	26
	1884.	105	193	105	90	40	27	29	19	52	10	28	62
	1885.	87	49	191	114	33	19	8	20	18	9	46	77
	1886.	72	111	65	114	40	36	22	24	17	11	29	38
	1887.	88	75	101	44	39	13	24	52	17	30	25	32
	1888.	73	108	99	101	29	24	9	19	50	37	72	66
	1889.	85	74	95	41	35	37	40	62	40	49	77	75
	1890.	73	82	85	93	49	39	21	16	35			
NESHAMINY.	1883.										12	25	21
	1884.	121	166	107	68	10	15	9	10	2	2	9	80
	1885.	93	105	177	98	23	5	2	15	3	3	34	60
	1886.	102	106	62	122	36	16	15	9	5	2	14	71
	1887.	91	78	91	46	33	23	24	21	10	19	16	47
	1888.	103	138	95	72	18	9	4	11	38	28	67	85
	1889.	81	82	86	43	30	22	44	71	41	50	74	100
	1890.	77	70	95	72	29	22	14	10	13			
TOHICKON.	1883.										20	35	24
	1884.	138	191	116	75	18	53	40	7	16	3	33	63
	1885.	103	74	190	148	23	9	10	15	7	7	55	58
	1886.	105	153	90	139	48	31	14	9	2	2	38	62
	1887.	119	96	125	42	36	21	20	37	12	13	18	49
	1888.	120	155	120	105	17	9	2	22	66	38	85	80
	1889.	99	64	105	58	31	33	52	81	43	51	90	97
	1890.	73	80	94	71	49	19	15	16	41			

MONTHLY PRECIPITATION ON THE WATERSHEDS.

	Year.	Jan.	Feb.	Mar.	Apr.	May.	Jun.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
PERKIOMEN.	1883.										5.27	1.93	4.00
	1884.	5.14	5.04	5.04	2.63	3.40	4.65	7.44	3.44	0.59	3.69	3.26	6.08
	1885.	3.76	4.41	1.32	2.41	2.49	1.48	2.18	6.17	0.87	4.74	3.88	3.18
	1886.	4.21	4.08	3.96	2.99	6.59	5.26	5.06	1.44	1.37	2.35	5.28	3.76
	1887.	4.55	5.63	2.99	2.84	1.85	5.87	8.63	2.76	3.64	1.45	1.61	6.65
	1888.	5.01	4.08	5.15	3.43	3.16	1.62	2.77	8.02	7.36	3.41	3.42	4.37
	1889.	3.86	1.99	3.17	5.04	4.55	7.16	12.23	3.99	7.00	4.78	8.67	1.70
	1890.	2.81	4.37	6.56	2.80	6.43	2.40	5.20	6.75	3.71			
NESHAMINY.	1883.										3.80	1.43	3.06
	1884.	5.58	6.27	5.20	2.42	3.37	5.42	5.92	5.13	0.21	3.05	3.69	5.70
	1885.	3.76	4.93	1.04	2.26	2.44	1.68	2.19	6.38	1.16	5.56	4.50	2.88
	1886.	5.11	6.18	3.72	2.93	5.79	5.67	5.40	1.60	0.91	2.77	3.92	3.30
	1887.	4.64	5.05	3.57	3.18	2.15	7.27	8.14	3.84	4.06	1.90	1.63	6.13
	1888.	4.47	3.98	5.15	3.88	2.87	2.34	3.71	5.78	6.93	3.76	3.49	3.72
	1889.	3.61	1.90	3.37	4.83	4.89	5.25	12.42	4.74	8.56	5.09	8.53	1.88
	1890.	2.08	4.28	5.36	2.46	5.20	4.51	4.47	5.30	3.00			
TOHICKON.	1883.										4.40	1.64	4.04
	1884.	5.32	5.45	5.19	2.52	3.54	6.48	7.05	3.99	0.46	4.00	3.51	6.26
	1885.	4.35	4.83	1.57	2.69	2.16	0.84	2.30	8.17	0.53	4.80	4.67	3.06
	1886.	4.15	6.01	4.76	3.42	7.14	4.53	5.48	1.09	1.30	2.59	5.16	3.83
	1887.	4.23	5.47	3.06	2.41	2.59	5.76	8.13	5.29	3.36	1.93	1.42	6.53
	1888.	5.31	4.34	5.23	4.08	3.03	1.69	3.20	8.07	8.32	4.06	3.67	4.34
	1889.	4.43	2.36	3.67	4.90	5.41	6.94	12.33	4.63	7.91	4.57	8.86	1.99
	1890.	2.82	4.72	6.77	2.48	6.30	3.93	5.81	5.75	2.99			

The observations kept at Fairmount, on the height of water flowing over the dam, show that 1889 exceeded any year since observations were begun. The total depth of water flowing over the dam, if it were all to pass over in one day, would equal 195 feet 10 inches in depth, and 1,112 feet in length, and this immense volume of water represents only 45 per cent. of the total rainfall on the 1,800 square miles of watershed area above Fairmount dam.

ANNUAL REPORT OF THE SECRETARY AND TREASURER.*

FOR THE FISCAL YEAR 1890.

January 10, 1891.

To the Officers and Members of the Engineers' Club of Philadelphia:

GENTLEMEN:—I have the honor to present the following statement of the receipts and expenditures of the Engineers' Club from January 11, 1890, to January 9, 1891, both inclusive.

Howard Murphy, Secretary and Treasurer, in account with The Engineers' Club of Philadelphia.

Dr.

Balance on hand January 11, 1890		$330 72
Initiation fees		105 00
Dues, 1887, Resident	$7 50	
" 1888, "	15 00	
" " Non-resident	10 00	
" 1889, Resident	60 00	
" " Non-resident	55 20	
" " Associate	7 50	
" 1890, Resident	735 50	
" " Non-resident	350 00	
" " Associate	45 00	
" 1891, Resident	655 00	
" " Non-resident	274 80	
" " Associate	10 00	
" 1892, Non-resident	5 00	
		2,230 50
Sales of Proceedings, Non-members		4 00
Advertisements, 1885	$36 00	
" 1886	40 00	
" 1887	32 00	
" 1888	136 00	
" 1889	198 00	
		442 00
Subscription to Decennial Reception		2 00
Local Contributions (J. Tatnall Lea)		100 00
Key deposit		50
		$3,214 72

* As amended by order of the Finance Committee.

PUBLICATION COMMITTEE.

Cr.

Rent	$1,000 00	
Gas	73 35	
Coal	101 50	
Janitor	240 00	
Ice	25 80	
House Expenses and Repairs	37 53	
		$1,478 18
Salary of Secretary and Treasurer.		1,000 00
Printer's Account.		313 81
Illustrations for Proceedings		164 14
Cataloguing and Arranging Library		144 84
Lunch		25 00
Sundries		69 88
Cash Balance forward to Account of 1891, *as per approval of Finance Committee*		18 87
		$3,214 72

MEETINGS.

Regular,	10
Business,	7
Total,	17

ATTENDANCE.

Members, total,	449
" average,	24+
Visitors, total,	28

Continuing the membership table from my last report:

	HON.	COR.	ACT.	ASSOC.
Membership at end of fiscal year 1889,	2	0	482	15
Additions,			23	2
			505	17
Decreased,			2	
			503	
Resignations,			28	1
			475	16
Transferred from Active to Associate,			1	1
	2	0	474	17

The residence of our Active Membership is now as follows:

Philadelphia,	208	Dakota,	1
Pennsylvania outside of Philadelphia,	92	Georgia,	1
New York,	42	Arizona,	1
Virginia,	27	Minnesota,	1
New Jersey,	19	Arkansas,	1
West Virginia,	9	New Hampshire,	1
Colorado,	7	Texas,	1
Massachusetts,	6	South America,	1
Maryland,	6	Japan,	1
Illinois,	5	India,	1
Kentucky,	4	Central America,	1
Indiana,	3	District of Columbia,	4
Connecticut,	3	Austria,	1
Delaware,	3	Indian Territory,	1
Missouri,	3	Washington,	1
North Carolina,	2	U. S. Colombia,	1
Alabama,	2	Rhode Island,	1
Tennessee,	2	Wisconsin,	1
Kansas,	2	Idaho,	1
Michigan,	2	New Zealand,	1
Ohio,	2	Ontario, Canada,	1
Vermont,	1		474

There have been but two deaths in our number during the year, but these both deserve special comment. Major Michaelis lost his life from an effort to rescue one of his children from drowning, under circumstances more than sad. Mr. Frederic Graff is the other. The Secretary feels that he offends no one when he says that in him we lost the leading member of our Club.

The following papers, etc., have been presented during the year:

Annual Address, by Mr. Wm. Sellers.

Opening Address, by Prof. H. W. Spangler.

Economical Form and Construction of Arches in Railroad Embankments, by Mr. Charles S. Churchill, with discussion by others.

Mr. Robert J. Parvin, Visitor, Photographs on the Improvement of the Mississippi River at Plum Point Beach.

Judson Pneumatic Railway, by Mr. John T. Boyd.

Pneumatic Railways in England, by Mr. T. Carpenter Smith.

Re-enforcement or Underpinning of the Iron Piles of a Draw-Bridge Pier, by Mr. Howard Constable.

Purifying Effect of Sand Filtration, by Mr. Barton H. Coffey. Discussion by Mr. Howard Murphy.

Sinking Dies, by Mr. Henry G. Morris.

Method of Towing Coal Barges on Western Rivers, by Mr. T. Carpenter Smith.

Recent Visit to Works of the Simonds Rolling Machine Co., at Fitchburg, Mass., by Mr. Wilfred Lewis.

Notes on Railroad Engineering Drawing, by Mr. Frank Cooper. Discussion by Messrs. Edward Hurst Brown, Prof. L. F. Rondinella and Howard Murphy.

A New Form of Steam Valve, in which packing is used instead of a ground seat, by Mr. Edwin S. Crawley. Discussion by Messrs. Henry G. Morris, Prof. H. W. Spangler and Howard Murphy.

New Shaft Coupling for the Transmission of Power, by Mr. Wilfred Lewis.

Purification of Water by Means of Metallic Iron, by Mr. Easton Devonshire, Visitor.

Mountain Railroads of Reading, by Mr. Wm. H. Dechant.

Interoceanic Canal Prospect in 1890, by Mr. J. Foster Crowell.

Physical Geography of the Mississippi River, by Prof. J. W. Redway.

Rail Joints, by Mr. Geo. W. Creighton.

A New Condensing and Refrigerating System, by Mr. Strickland L. Kneass.

Granolithic Pavements, by Mr. Robert A. Cummings. Discussion by Mr. Edward Hurst Brown.

New Method of Making Barrels by Machinery, by Mr. Arthur Falkenau. Discussion by Messrs. Henry G. Morris, Wilfred Lewis, John C. Trautwine, Jr., Max Livingston and the author.

Application of Drain Tiling, by Mr. Benjamin Franklin. Discussion.

Topographical Surveying, by Mr. Harvey Linton.

Continuous Rails for Railways, by Mr. R. Taylor Gleaves. Discussion.

The Abnormal Rainfall in the Vicinity of Philadelphia in 1889, by Mr. John E. Codman.

Condition of an Elastic Fluid During Discharge through an Orifice, by Mr. Strickland L. Kneass. Discussion by Prof. H. W. Spangler, and Messrs. Wilfred Lewis, J. C. Trautwine, Jr., Dr. H. M. Chance and Mr. Howard Murphy.

Feed Rachet, by Mr. Wilfred Lewis.

Suburban Development, by Mr. Edward Hurst Brown. Discussion by Messrs. Henry G. Morris, Robert J. Parvin, A. G. Rudderow and C. H. Ott.

Use of a Pumping Dredge by the Norfolk Company at Norfolk, Va., by Mr. John Graham, Jr. Discussion by Mr. Robert J. Parvin.

Crown Bar Stays, by Mr. G. R. Henderson. Discussion.

Shingle for Concrete and Béton, by Mr. Charles H. Haswell. Discussion by Dr. H. M. Chance and Mr. Howard Murphy.

Respectfully submitted,

Howard Murphy, *Secretary and Treasurer.*

NOTES AND COMMUNICATIONS.

A NEW SHAFT COUPLING.

Business Meeting, April 19th, 1890.—Mr. Wilfred Lewis presented the following:

The shaft coupling which I have to exhibit this evening is the final result of several attempts to join the ends of two shafts by a mechanical union no larger in section than the shafts themselves, and of maximum strength, stiffness and durability.

In its present form, the coupling has passed through an experimental existence in the hands of Wm. Sellers & Co., Incorporated, and is thought to have sufficient merit to be worthy of the patent which was granted for it a few months ago. It is not, therefore, strictly speaking, a brand new thing, but it occurred to me that some account of the failures that led to its invention, together with the tests to which the joint has recently been subjected, might be of interest to the Club. The need of such a coupling came to my attention about six years ago, while working up the design for a traveling crane to be driven by a square shaft with a sliding sleeve.

Quite a number of methods of accomplishing the desired result suggested themselves, and of these I may mention the welded joint, the scarfed joint, the double-scarfed joint, and a notched joint with a central pin holding the notched ends of two shafts together.

The welded joint, when well made on wrought iron or soft steel shafts, is undoubtedly superior to any other in strength, stiffness, and durability, but it is not a convenient joint to put together or take apart in a line of shafting supported on tumbler bearings, often thirty or forty feet high. In making such a joint, the alignment must be carefully preserved, and the length of the shaft, when finished, must be reasonably accurate on account of spacing the tumbler bearings. Electric welding might be employed to advantage on small shafts, but it does not seem practicable as yet to weld shafts from two and a half to three and a half inches square in place by that method.

One objection to the welded joint may be raised on account of the deterioration suffered in some grades of steel by unequal heating, but the most serious objection to it lies in the difficulties which attend the operation of welding in place.

The scarfed joint was considered and rejected on account of its inherent weakness, all the strains passing through it being transmitted by the uniting rivets.

The double-scarfed joint had decided advantages over the single scarf in the transmission of torsional strain, and for bending strain the rivets acted in double instead of single shear, but still the rivets were subject to strain in every direction, and were consequently liable to work loose.

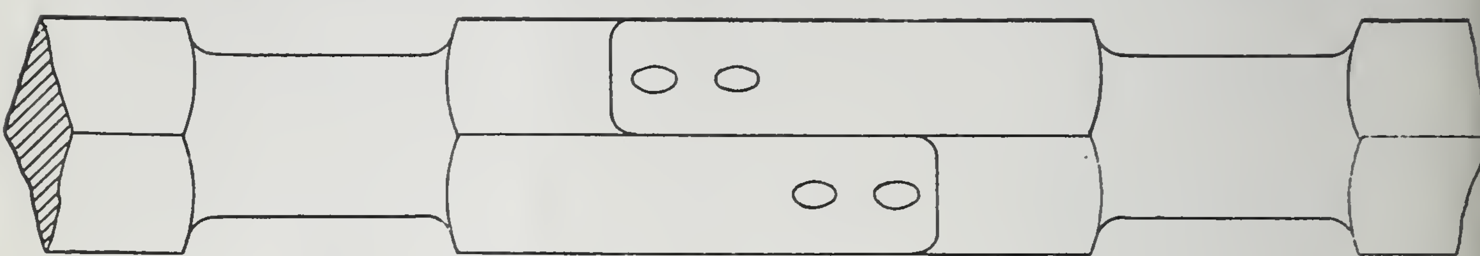
The double-scarfed joint was, therefore, rejected also as impracticable.

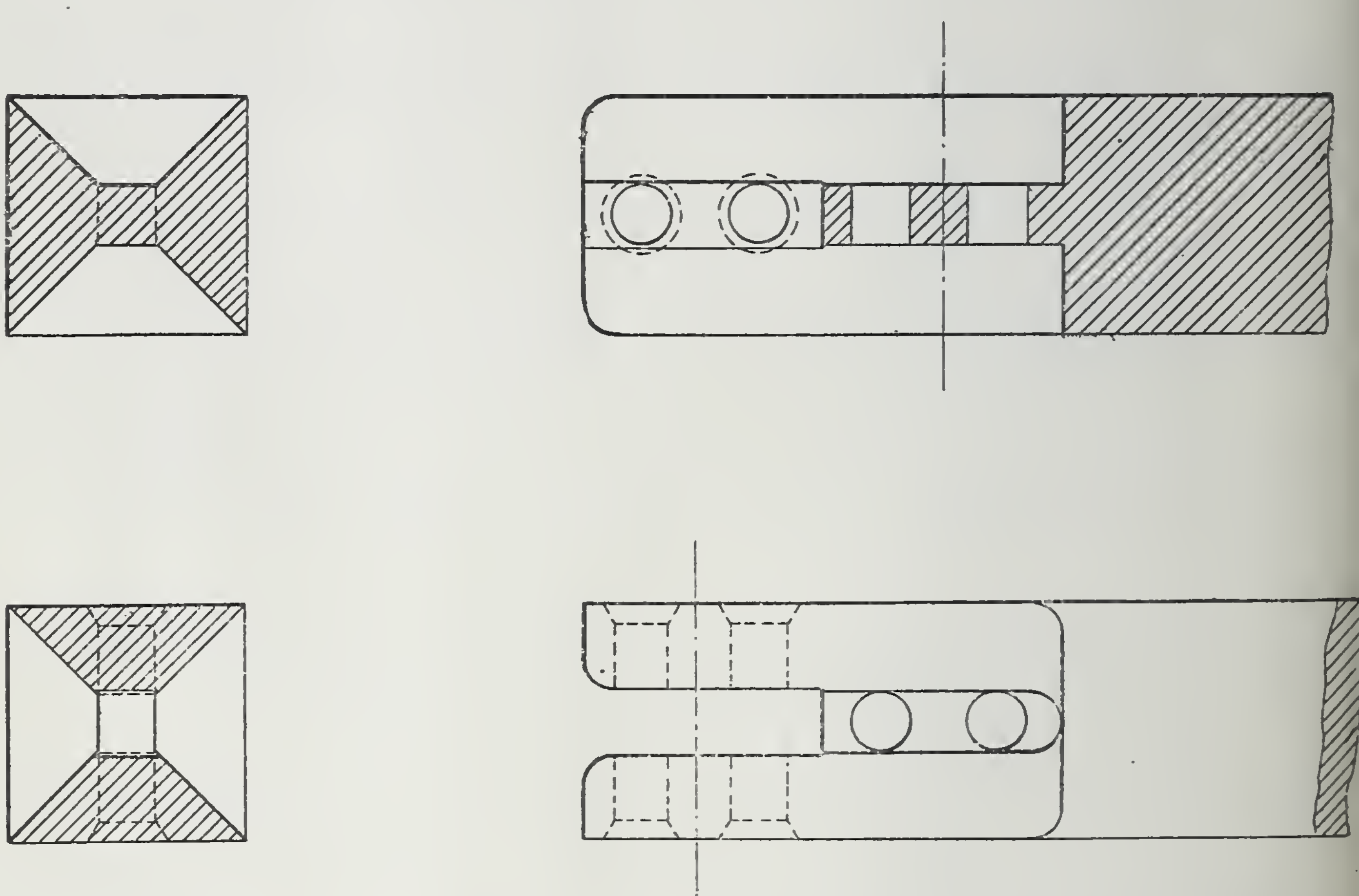
To avoid the difficulty of constructing a rigid joint capable of sustaining transverse as well as torsional strain, a loose joint was contrived by simply notching the ends of two shafts, and uniting them by a pin in the axis of the shaft held by cross pins or rivets at the ends.

This joint was theoretically much stronger than the scarfed joints for torsion, and being comparatively flexible, it was expected that the necessity for very accurate

alignment would be thereby avoided. But this expectation was not realized, and, after a few months in service, the wear on the driving surfaces began to be apparent. To reduce this tendency to wear, care was taken to perfect the alignment, and in subsequent joints the notches were cut deeper. It was evident, however, that something better was needed, a loose joint being subject to wear from imperfect alignment, and all rigid joints, hitherto considered, being laterally weak.

The coupling now before you was designed to remedy all the difficulties and defects which I have just pointed out. It may be described as a combination of interlocking grooves and tongues united by rivets. The shaft is grooved on planes passing





through its corners, the space between the bottoms of the grooves forming a strong web, which is slotted from the end for half its length. When put together, the tongues on one shaft are drawn up by rivets passing through the web on the other shaft. The rivets thus bring the driving surfaces into close contact, and the joint is not liable to rub when out of alignment, on account of its length and lateral stiffness. Furthermore, there can be no strain on the rivets other than the initial strain under which they are set, and they are, therefore, not liable to work loose. To take the joint apart it is simply necessary to chip off the heads of the rivets and drive them

our. These couplings are all fittted up to gauges, and the rivet holes are drilled after the shafts are put together.

In regard to strength, stiffness and durability, the three requisites for a good coupling, the problem appears to be satisfactorily solved.

To ascertain the torsional and transverse strength of the joint, the samples on exhibition have been tested to destruction, or nearly so, in the following manner: A short piece of coupled shafting, two and a half inches square, was fastened at one end, while the other end was supported so as to be twisted by a weighted lever.

A load of 1,000 lbs., at eighty-five inches rad., twisted the joint about 15°, and permanent set began to take place at about half this amount, showing it to be good for a twisting moment of 42,500 inch-pounds.

To compare the strength of the joint with that of the solid shaft and ascertain accurately the elastic limit of the material, the shaft was turned down to $1\frac{3}{4}$ inches diameter, 6 inches long, and loaded as before by a weighted lever. In this manner the elastic limit of the journal was ascertained to be reached at 33,320 in.-lbs. When a permanent set of 20° had taken place, the resistance was 57,700 in.-lbs., and when twisted 90° it was 66,940 in.-lbs.

If this load had been continued, the joint would probably have twisted off. To compare the strength of the joint with that of the square shaft, we can say that for like defections a two and a half-inch joint carries 85,000 in.-lbs. against 57,700 in.-lbs. for a one and three-fourths-inch journal. From this it appears that a two and a half-inch joint is about equal in strength to a two-inch journal. But a two-inch journal has only .42 of the elastic strength of a two and a half-inch square shaft, and, therefore, the joint under consideration may be said to have about $\frac{7}{16}$ of the strength of the solid shaft. The most that could be expected of a mechanical union of any kind would be fifty per cent., because half of one shaft must be cut away to make a joint for the other. Allowing 10,000 lbs. fiber stress as a safe working limit, it appears from the foregoing that a good rule for the working strength of this coupling would be $BM = 1{,}000\ d^3$, in which $BM =$ twisting moment and $d =$ side of square.

Having tested the joint for twisting, it was desirable that it should also be tested for bending, and a new joint was made for the purpose. This joint was clamped to a planer table, a long extension lever was added, and loads were gradually applied to determine the elastic limit and ultimate strength. No perceptible set took place until a load of 27,000 in.-lbs. was reached, after which the set gradually increased, until at 108,000 in.-lbs. it was evident that the ultimate strength would soon be reached. The joint continued to deflect, however, until 144,000 in.-lbs. were reached, when it broke by shearing the rivets and prying off the upper part. Similarly the solid shaft was tested and found to deflect permanently at 160,000 in.-lbs., and the deflection was continued until, under a load of 300,000 in.-lbs., it amounted to a bend of about 20°. Under this load the set increased so rapidly that it may be taken as a measure of the ultimate strength.

Here again the transverse strength of the joint appears to be nearly half as great as that of the solid shaft, but the elastic strength is less than one-fifth. This low, elastic limit is probably due to the slip which takes place between the fitted surfaces, but even at 27,000 in.-lbs. the joint is very stiff indeed, and up to all ordinary requirements. The only transverse strain that can come upon it is that due to imperfect alignment, and being placed, as it always is, near a journal, the flexibility of the

journal can be made to relieve the joint. For this purpose the journal is made small enough to equal the joint in torsional strength, or .8 of the diam. of the square shaft, and it thus becomes flexible enough to relieve the joint without weakening the shaft. As an additional relief, the shaft is sometimes turned down on both sides of the joint to the diam. just given. The material used in these experiments was cold-drawn steel of very good quality. The elastic limit for torsion was about 33,000 lbs. per square inch, and that for bending about 60,000 lbs. per square inch.

In durability the joint promises well, but as it has in no case been in use for more than two years, it may be premature to say that it is quite equal to a weld. Thus far there has been no complaint that I know of against the present form of joint. To insure torsional stiffness and obtain large wearing surfaces, it is customary to use large factors of safety, and the reduction of strength at the joints and journals is not often a serious matter, because the shaft would be just as large if welded.

It may be said in conclusion that the joint is applicable to round shafts as well as to square. It is not expected, however, that it will supersede any of the common forms of couplings now used for shafting; but in special cases, where the ordinary coupling becomes a serious obstruction, this joint approaches in strength and stiffness all that can be expected of a mechanical union no larger in section than the shafts themselves.

ABSTRACT OF MINUTES OF MEETINGS.

OF THE CLUB.

JANUARY 10, 1891.—Thirteenth Annual Meeting.—President H. W. Spangler in the chair; 49 members present.

Minutes of Business Meeting, December 6, 1890, were approved.

The Tellers of Election, Messrs. John S. Mucklé, A. E. Lehman and Henry G. Morris, reported that 203 votes had been cast and that the following had been elected:

OFFICERS FOR 1891.*

President,
Wilfred Lewis.

Vice-President,
S. M. Prevost.

Secretary and Treasurer,
Howard Murphy.

Directors,

Rudolph Hering, F. H. Lewis,
Percival Roberts, Jr., P. G. Salom,
Geo. S. Webster,

and the following to Active Membership: Messrs. W. P. Dallett, Clark Dillenbeck, Thomas S. R. Flickwir, Baird Halberstadt,

* After the adoption of the new Constitution and By-Laws, and on account of resignations from office, the Officers, after March 14, 1891, became as follows:

President,
Wilfred Lewis.

Vice-Presidents,
David Townsend, S. H. Chauvenet.

Secretary,
Howard Murphy.

Treasurer,
T. Carpenter Smith.

Directors,

Rudolph Hering, H. W. Spangler,
Frederick H. Lewis, John C. Trautwine, Jr.,
Pedro G. Salom, George S. Webster.

Edwin R. Keller, Edgar Piercy and Joseph Schreiber; and to Associate Membership, Mr. Thos. S. Parvin.

The retiring President, Prof. H. W. Spangler, delivered the Annual Address.

The Secretary and Treasurer presented his Annual Report, and moved that his accounts be referred to the Finance Committee of the incoming Board to be audited.

Mr. Wilfred Lewis then took the chair, with appropriate remarks. He specially urged earnest activity and energy on the part of everyone in promoting the interests of the Club; maintaining that the Club should not be satisfied with its present position, and that there should be no limit to the expansion of its usefulness.

The following resignations from Active Membership were accepted: Messrs. F. H. Corlies, Edwin S. Crawley, Aug. Dietz, Geo. H. Frost, John Haug, T. J. Lewis, Dr. Wm. H. McFadden, James H. Nichol, Frederick H. Robinson, Fred. W. Taylor and T. L. Welles; and from Associate Membership, Messrs. F. K. Esherick, W. C. Strawbridge and J. Bonsall Taylor.

An amendment was offered to the By-Laws, providing for a change in the nights of meeting, and an amendment to the Constitution and By-Laws, providing that some members of the Board should hold over each year; but, after some discussion, on motion of Mr. David Townsend, it was ordered that a committee of three be appointed to revise the By-Laws, and the above-mentioned amendments were referred, by consent, to this committee, with instructions to report on the third Saturday of February.

The Secretary moved that a Social Committee be appointed, with Mr. Robert J. Parvin as its Chairman, which was so ordered.

The Secretary was instructed to issue postal cards to the resident members of the Club, prepared in blank, for members to express their preferences as to the nights on which meetings be held.

Mr. H. C. Lüders spoke of the desirability of making an arrangement by which several members would be present at the Club House every evening, to receive any others who might call. This question was referred to the Social Committee.

The meeting then adjourned to lunch.

JANUARY 17, 1891.—Regular Meeting.—President Wilfred Lewis in the chair; 19 members present.

The minutes of last Regular Meeting, December 20, 1890, were approved.

The Secretary presented, for Mr. Geo. R. Henderson, an illustrated paper upon Locomotive Driving Springs.

Mr. Carl Hering read a paper on a Portable Photometer for Measuring Street Lights and Illumination in General.

The meeting then adjourned to lunch.

FEBRUARY 7, 1891.—Regular Meeting.—Past-President Rudolph Hering in the chair; 18 members present.

The minutes of last Regular Meeting, January 17, 1891, were approved.

Mr. Chas. H. Haupt presented an illustrated paper on Photographic Surveying, upon which considerable discussion followed.

The Secretary presented, for Mr. J. M. Stewart, a paper by Mr. J. Bernard Walker upon a Boltless Rail Joint. Mr. Stewart, who is Chief Engineer of the Oregon Pacific Railroad Company, is about to try it on his road, and considers that one of its principal values is that such rail joints will be cheap to maintain, as the constant tightening of bolts is not, in his opinion, necessary.

The meeting then adjourned to lunch.

FEBRUARY 21, 1891.—Business Meeting.—President Wilfred Lewis in the chair; 45 members present.

The minutes of the Thirteenth Annual Meeting, January 10, 1891, were approved.

The report of the Committee on the Revision of the Constitution and By-Laws was presented by Mr. T. Carpenter Smith, the Secretary of the Committee.

On motion, the report was adopted and the Committee discharged.

Prof. H. W. Spangler then offered the amendments proposed by the Committee, together with the following resolution:

Resolved, That the Secretary be directed to put the report of the Committee in type, excepting the proposed new Constitution and By-Laws, and that he also put in type the amendments proposed

by Messrs. Morris, Spangler, Cleemann, Jones, deKinder and Lewis, and mail a copy of each of these documents to each member of the Club, together with a copy of our present Constitution and By-Laws, and the necessary direction for voting on these amendments at the next meeting of the Club.

This resolution was adopted, and it was ordered that the next meeting of the Club be a Business Meeting.

The Secretary presented resignations from membership. On motion of Mr. T. Carpenter Smith, these were laid over until the vote is received on the proposed new Constitution and By-Laws.

The Secretary inquired whether the vote upon the proposed new Constitution and By-Laws should be upon each section separately or as a whole.

On motion of Prof. H. W. Spangler it was ordered that votes must be cast upon the said proposed new Constitution and By-Laws as a whole.

The Secretary then presented, for Mr. Percy T. Osborne, a large view of the Rivermont Bridge at Lynchburg, Va., accompanied by a communication describing this structure.

Mr. Rudolph Hering presented a paper upon the Action of Sea Water on Steel and Iron.

This paper was followed by some discussion; but as Mr. Hering proposed to continue the subject at a future meeting, it was resolved that further discussion be postponed until the completion of the paper by Mr. Hering.

The meeting then adjourned to lunch.

March 7, 1891.—Business Meeting.—President Wilfred Lewis in the chair; 38 members present.

The minutes of Business Meeting, February 21, 1891, were approved.

Mr. S. L. Kneass, Chairman of the Tellers of Election, reported that 115 legal votes had been cast upon the new Constitution and By-Laws, 108 being in favor thereof, and 7 against. The new Constitution and By-Laws were, therefore, adopted.

Certain resignations were referred to the Board of Directors, with the request that the Board solicit their withdrawal in view of the adoption of the new Constitution and By-Laws.

The Secretary presented, for Mr. J. J. Hoopes, notes on the Mississippi River Discharge.

The Secretary presented, for Mr. C. B. Hunt, notes on Street Cleaning in Washington, D. C.

There was some discussion by Messrs. E. V. d'Invilliers and Rudolph Hering, and, on motion of Mr. John C. Trautwine, Jr., the subject of Street Cleaning on Asphaltum and other smooth pavements was referred to the Committee of the Board on Information and Entertainment, to report to the Club as to the practice in this matter in various important cities.

The Secretary presented, for Mr. Howard Constable, a description of the Re-enforcement of Foundation in a Drawbridge Pier.

Mr. Rudolph Hering continued reading a paper on the Corrosion of Iron and Steel, and referred to Galvanic Action as a principal cause. He gave the results of experiments on this subject, and principally of those made by Mr. Thomas Andrews, of England. Wrought iron was placed in connection with numerous steels and cast iron, and exposed to sea water for about 300 days. From these it was found that metals corroded much faster when in galvanic connection than otherwise. The wrought iron (Wortley best scrap) resisted corrosion better than either steel or cast iron. The electro-chemical position of the steel changed frequently with reference to wrought iron, indicating that corrosion took place alternately in the wrought iron and steel. The position was almost constant, however, when connecting wrought iron and cast iron, indicating that the corrosion takes place almost entirely in the latter. Gravimetrical results were also given, which showed the amount of corrosion in grains per square foot, per annum, under the conditions assumed in the experiments.

The question of inserting authors' names in notices, together with the titles of their papers, was, on motion of Mr. E. V. d'Invilliers, referred to the Information and Entertainment Committee.

March 21, 1891.—Regular Meeting.—President Wilfred Lewis in the chair; 22 members and 1 visitor present.

The minutes of Regular Meeting, February 7, 1891, were approved.

The Secretary made the following announcements:

That Mr. S. M. Prevost had resigned from the Vice-Presidency of the Club, and that Mr. David Townsend had been elected as his successor.

That the Board had elected Mr. S. H. Chauvenet as Vice-President, in accordance with the Enacting Clause of the new Constitution and By-Laws, and, under the same clause, Prof. H. W. Spangler was elected the new member of the Board, and Mr. T. Carpenter Smith was elected Treasurer of the Club.

That the Standing Committees of the Board of Directors, as finally appointed by the President, are as follows:

Finance—Messrs. P. G. Salom, F. H. Lewis and S. H. Chauvenet.

Membership—Messrs. David Townsend, P. G. Salom and S. H. Chauvenet.

Publication—Messrs. Rudolph Hering and John C. Trautwine, Jr., and Prof. H. W. Spangler.

Library—Messrs. George S. Webster, Rudolph Hering and P. G. Salom.

Information and Entertainment — Prof. H. W. Spangler and Messrs. George S. Webster and F. H. Lewis.

House—Messrs. F. H. Lewis, John C. Trautwine, Jr., and David Townsend.

The Secretary presented, for Mr. Harry B. Hirsh, an illustrated description of an Iron Sewer Template which had been used in the construction of a cement sewer.

Mr. Strickland L. Kneass presented notes on the Discharge of Steam into the atmosphere through tubes of different shapes, with pressures from 30 to 120 pounds per square inch.

There was some discussion of this paper by Mr. T. Carpenter Smith, Prof. H. W. Spangler, Mr. Wilfred Lewis and the author.

The meeting then adjourned to lunch.

Of the Board of Directors.

January 3, 1891.—Special Meeting.—President H. W. Spangler in the chair. Present—Messrs. Wilfred Lewis, E. V. d'Invilliers and Henry G. Morris.

The Board appointed as Tellers to conduct the Annual Election Messrs. T. M. Cleemann and A. E. Lehman, and as Alternates Messrs. Henry G. Morris and John S. Mucklé.

January 10, 1891.—Special Meeting.—President H. W. Spangler in the chair. Present—Messrs. Lewis and Morris.

The Board took no action, except to approve the minutes of their Special Meeting on January 3, 1891, and to adjourn.

January 17, 1891.—Regular Meeting.—President Wilfred Lewis in the chair. Present—Messrs. F. H. Lewis, Hering and Salom.

The President announced the Standing Committees of the Board for the year 1891. (See List of Committees, as revised, below.)

The Secretary presented a form for postal card which he had prepared to issue to Resident Members of the Club, so as to obtain their views with reference to changing the nights of meeting of the Club. This form was approved by the Board.

The Secretary suggested that the courtesies of the Club House be extended to the members of the Master Car Builders' Association when they might be in Philadelphia in connection with their meeting at Cape May in June.

Mr. Hering also suggested that the same courtesy be extended to the members of the American Water Works Association which is expected to meet in Philadelphia this Spring.

On motion it was ordered that the Secretary confer with these societies, by correspondence or otherwise, and ascertain in what way the Club could best make their visit in Philadelphia pleasant.

The Secretary suggested that the wages of the Janitor, who is required to do a very considerable amount of additional work on account of the lunches after each meeting, be increased. On motion of Mr. Hering it was ordered that the Janitor's wages be increased $5 per month, if, in the opinion of the Finance Committee, the finances of the Club would admit of this increase.

On motion of Mr. Lewis it was ordered that the Finance Committee investigate the matter of members in arrears.

The Secretary suggested that the matter of lunches to be served

after each meeting be referred to the House Committee, with power to act, and it was so ordered.

February 21, 1891.—Regular Meeting.—President Wilfred Lewis in the chair. Present—Messrs. Hering, Salom and Webster, also Mr. John C. Trautwine, Jr., elected this evening.

The Secretary presented the resignation of Mr. Percival Roberts, Jr., from membership in the Board, which was accepted, and, on motion of Mr. Salom, Mr. John C. Trautwine, Jr., was elected to succeed Mr. Roberts.

The President appointed Mr. Trautwine to succeed Mr. Roberts on the Standing Committees, with the understanding that Mr. Salom should be Chairman of the Finance Committee. (See List of Committees, as revised, below.)

The Secretary presented a petition for charity from the Protestant Episcopal City Mission, and was directed to reply to the effect that the Club had no fund set apart for such purposes.

The Secretary presented a communication with regard to the participation of the Club in the formation of a Pennsylvania State Library Association. This communication was referred to the Library Committee.

The Secretary presented a communication from Mr. John W. Weston, Secretary of the Western Society of Engineers, with reference to the appointment by the Club of a member of a permanent committee on the proposed Engineering Congress and Engineering Headquarters at Chicago during the approaching World's Fair. This communication was referred to the President, with power to act.

The Secretary called the attention of the Board to the fact that a stepping-stone was on the curb of the Club House, and that as such appliances are regarded as useless and an obstruction to public travel, he asked that he be authorized to request its removal by the Girard Estate. On motion it was so ordered.

March 14, 1891.—Special Meeting.—President Wilfred Lewis in the chair. Present—Messrs. Salom, Webster, F. H. Lewis, Trautwine and Hering.

The resignation of Mr. S. M. Prevost from the Vice-Presidency of the Club was read and accepted.

The President presented a commuication from Mr. J. Foster Crowell with regard to the Club and its publications.

Mr. David Townsend was elected Vice-President to succeed Mr. S. M. Prevost.

Mr. S. H. Chauvenet was elected Vice-President in accordance with the enacting clause of the new Constitution and By-Laws, and, under the same clause, Prof. H. W. Spangler was elected the additional member of the Board, and Mr. T. Carpenter Smith was elected Treasurer of the Club.

A motion to make the salary of the Treasurer at the rate of $60 per annum was laid on the table.

Announcement was made of the appointment by the President of the Standing Committees of the Board. (See List of Committees, as revised, below.)

The matter of writing to members who had tendered their resignations, urging them to continue as members of the Club, in view of the adoption of the new Constitution and By-Laws, was referred to the Membership Committee, with power to act.

It was ordered that the signature or approval of two members of any committee to any document or movement shall be considered as the action of the committee, and shall commit the entire committee in the premises.

March 21, 1891.—Regular Meeting.—President Wilfred Lewis in the chair. Present—Messrs. Townsend, Spangler, Trautwine, Salom and F. H. Lewis.

The President changed Mr. Chauvenet from the Publication to the Membership Committee, and Prof. Spangler from the Membership to the Publication Committee.

The Standing Committees for the year are, therefore, finally as follows:

Finance—Messrs. P. G. Salom, F. H. Lewis and S. H. Chauvenet.

Membership—Messrs. David Townsend, P. G. Salom and S. H. Chauvenet.

Publication—Messrs. Rudolph Hering, John C. Trautwine, Jr., and Prof. H. W. Spangler.

Library—Geo. S. Webster, Rudolph Hering and P. G. Salom.

Information and Entertainment—Prof. H. W. Spangler, Geo. S. Webster and F. H. Lewis.

House — Messrs. F. H. Lewis, John C. Trautwine, Jr., and David Townsend.

The Finance Committee reported that they had audited the accounts of the Treasurer for the fiscal year 1890, and had found them to be correct. They also recommended that steps be taken to collect dues from members in arrears. This report was accepted.

On motion of Prof. Spangler it was ordered that the recommendations contained in the report be adopted, provided that action as to delinquents be referred to the Membership Committee, with power to act, the understanding being that the intention is to retain as many members as possible in the Club, and, at the same time, secure the payment of their dues.

It was ordered that hereafter the Regular Meetings of the Board be held on the third Saturday of each month, except July and August, at 4.30 P.M.

MARCH 28, 1891.—Special Meeting.—President Wilfred Lewis in the chair. Present—Messrs. Townsend, Spangler, Hering, Trautwine and Salom, also Mr. T. Carpenter Smith, Treasurer.

The Secretary presented various accounts and documents which he had kept when Secretary and Treasurer of the Club, and had prepared so as to inform the Board as to the standing of various accounts, etc. All of these matters were referred to the Finance Committee in connection with the Secretary and the Treasurer.

Mr. Trautwine presented several matters with regard to the Publications of the Club, concerning the sizes desirable for copies of the Constitution and By-Laws, notices, circulars and other forms, and, on motion, all matters of this class were referred to the Publication Committee, with power to act.

Mr. David Townsend presented a report on the matter of letters to be sent to members whose resignations have been received but not acted upon, and also as to the desirability of increasing the membership of the Club, recommending that applications for membership be sent to each member of the Club, with the request that each member shall endeavor to induce the proper kind of persons to join the Club.

This report was adopted.

BOOK NOTICES.

The Civil Engineer's Pocket Book. By John C. Trautwine, C.E. 15th edition, 40th thousand. John Wiley & Sons, New York, 1891.

According to the preface, the principal new features in this edition are the greatly enlarged article on Weirs, with suggestions for small measuring weirs, and that on Centrifugal Force. A number of minor changes have also been made.

American Railroad Bridges. By Theodore Cooper. New York: Engineering News Publishing Company.

This book, constituting the paper read by Mr. Cooper at the Seabright meeting of the American Society of Civil Engineers, is now on our shelves, by the gift of the author; and the Club, in common with the entire engineering profession, is indebted to Mr. Cooper for the large amount of time and disinterested work which he has given to the preparation of this monograph. But then we are indebted to Mr. Cooper for many good things, as indeed, lest any one should forget it, Mr. Cooper explains in the book now in question, having no notion, we take it, of putting his light under a bushel. And, indeed, why should he in this latter end of the nineteenth century?

Much of the historical information in regard to the older bridges, which has been gathered together by the author, would no doubt have soon been lost if some one had not undertaken the work at this time, and its historical value is, therefore, undoubted.

Any one who reads the book carefully, however, will not fail to see that the author had another idea in view in preparing the paper. There can be no doubt that Mr. Cooper has felt it desirable to make an adequate reply to certain adverse criticisms of the American bridge *per se*, which have appeared in recent years in connection with the matter of bridge failures. This part of the subject is treated in the latter part of the book, and is handled by the author with unusual skill and force; of this more further on.

Of the earlier bridges of the eighteenth century, a majority are in the New England States; but of those built in the nineteenth century and of the earlier iron bridges, dating from 1850 or thereabouts, a notable number are in the State of Pennsylvania or near its borders.

The first of these noticed in the book is our familiar Market

Street Bridge, known under the title of the "Permanent Bridge" over the Schuylkill River. If one of our chief daily papers is to be considered an authority in the matter, the Legislature made it "permanent" by law, so that it might not fall down, as our earlier bridges had a habit of doing. It, however, was torn down and replaced in 1850 by a more modern bridge; carrying a part of the Pennsylvania Railroad's freight business. This structure was unfortunately burned down in 1874, and was then replaced by a temporary bridge, built by the Pennsylvania Railroad in less than sixty days and guaranteed for five years. This temporary bridge, however, actually lasted fifteen years, and was finally replaced in 1889 by the new cantilever iron bridge, with which we are all familiar.

The bridge erected by Timothy Palmer in 1805 at Easton, Pa., is still standing there in apparently good condition and in daily use.

Of the old bridge over the Susquehanna River at Harrisburg, built in 1812–16, one-half is also still standing, presenting a peculiar appearance with its exaggerated camber and making a picturesque object in the landscape, familiar to all who have crossed into the Cumberland Valley from Harrisburg.

Following the wooden bridges, Mr. Cooper treats as usual of the well-known early works of Fink, Bollman, Whipple, etc.

Among the earlier iron bridges Mr. Cooper notes the bridge built by Mr. Lowthorp, in '57, on the Catasauqua & Fogelsville Railroad, consisting of eleven spans of about 135 feet each, on iron trestles. This bridge, which is known as the Jordan's Creek Bridge, located about four miles south of Catasauqua, was taken down a couple of years ago and replaced by a modern structure, built by Edge Moor Bridge Works. It was stated at the time that the old bridge showed no signs of weakness or failure, but was taken down because it was thought it had been there about long enough. It had, therefore, been in use thirty-two years, carrying a heavy ore traffic to the furnaces in Catasauqua.

The Whipple Bridge over the Saucon Creek at Bethlehem, which was built by Murphy in '56, is stated in the book to be still standing, although it had never been used at all. The structure has been taken down since Mr. Cooper wrote, though we do not know what has become of it. It is a pity we have no museum for our old bridge structures, where things like these might be stowed away for examination.

The Arsenal Bridge here at Philadelphia, described by Mr. Cooper as having been built in '61, and containing the first forged eye-bars and wrought-iron posts, was also taken down

a short time ago, after twenty-eight years of service. Its removal was probably due to the great increase in rolling loads, rather than to any serious deterioration in the structure itself.

Mr. Slataper's bridge across the Allegheny River at Pittsburgh, which was built in '64, still stands and seems likely to stand indefinitely, under a very heavy traffic. It is, however, wrought iron throughout, and in construction is one of the strongest types of riveted lattice bridges ever designed or built; being undoubtedly better, with respect to design, than the riveted lattice bridges now in vogue.

We look with surprise at some of the older long-span bridges, illustrated in the book. Especially noticeable is the 320 feet span over the Ohio River at Steubenville, with the cross-ties resting directly on the eye-bars of the bottom chord, just as they have done indeed in many other old bridges which have stood for years, with eye-bars apparently none the worse for the heavy transverse bending strains which come upon them. The bridge has also been replaced within the last two years, we believe.

The excellences of this book are so considerable, at all points, that we are compelled to speak of each new part as especially interesting. The part relating to designing and proportioning is admirable in all respects. We, as Philadelphians, would, of course, like to see a fuller notice of and comment on our old friend, Gen. Herman Haupt, whose treatise on the subject of bridges is familiar to all engineers.

The modern methods of bridge building, however, undoubtedly date from the construction of the St. Louis Bridge and the bridges of the Cincinnati Southern Railroad. The inductive methods by which the engineers of these structures reached their conclusions, both as to strains and as to proportioning the members, established a course of procedure which we are still successfully following. Mr. Bouscaren's part in the matter is perhaps greater than that of any other individual, and the profession is greatly indebted to this accomplished engineer for the work which he did on the Cincinnati Southern Railroad, both for improvements in design and in the method of inspection and tests, which he adopted and first reduced to a system. His use of the engine and train diagram, instead of a uniform fixed load, struck at the most notable mistake of the old designers. They failed to appreciate the effect of engine loads on short spans; hence all the old bridges had floor systems which were much too light. The table of equivalent loads which is given in this connection shows this up forcibly. The effect of a uniform load of 2240 lbs. on a 350-ft. span is precisely the same as that due to the Cincinnati Southern train load, but on a 10-ft. span the uniform load gives 2240 lbs. per ft., while

the Cincinnati Southern loading gives 4800 lbs., or more than twice as much.

This mistake of the early designers has been the cause of the wholesale rejection of a great number of old bridges, and constitutes the reason why none of our iron bridges have had a chance to wear out, or to show how long they would continue in use without wearing out. Some of the old floor systems have had to carry, and have actually carried, loads which have taxed the metal to 30,000 lbs. or more to the square inch;—no wonder some of them failed.

The method of moments is described in general terms by Mr. Cooper, its development being in fact largely due to his own work and investigations. It is, to-day, the bridge engineer's stand-by in calculating strains, and has apparently put a quietus on the graphical methods which seemed likely to come largely into use a few years ago. In practice it has proved so efficient that graphics are now used only to help out the analytical work occasionally.

There is probably nothing better in the book than the simple rule for camber. For this rule, which is at once the simplest and the most correct rule now in use, we are indebted also to the joint efforts of Messrs. Cooper and Escobar. It is believed to have been used first by Mr. Escobar, and to have first been put in specifications by Mr. Cooper. It is based entirely on the theory of elasticity, and, while being so essentially simple, it is theoretically correct at all points.

Nevertheless, it is still the fact that the majority of the bridges are figured on the old rule for camber, viz.: that the versin of the chord shall equal one twelve-hundredth of the span. Now it is certainly remarkable that this old rule, which is bothersome in practice and entirely wrong in theory, should hold its own in the way it does. Theoretically it is in error because it is based on but one element of the bridge—that is its length—while deflection is a function of the depth of the girder. Practically it is bothersome because in employing it we must first estimate the versin of the chord and then figure, by formula, the length of the chord to produce this versin in the bridge after it is up. As compared with this, how much easier it is to allow simply one-eighth of an inch additional length to the upper chord for every ten feet of span! The versin then adjusts itself exactly to the conditions required by the laws of elasticity. The deeper the truss, the less the rise of the chord; and the less the depth of the truss, the greater its rise.

We have endeavored to ascertain the origin of the old rule, but unsuccessfully. It occurs to us that perhaps the old fellow who

originated it did know just what he was about, and that people since have misunderstood his meaning. Camber may mean either one of two things: either the versin, or the allowance put in the chord to produce this rise. The origin of the word is, of course, the French word *cambrer*, to bend or curve, and a curve may very readily be designated by its versin; but, for practical purposes, the camber is the added length we put into the top chord, and, as we talk of it, may mean that. Now, if the engineer who formulated the rule that the camber should be 1-1200th of the span had meant that *the allowance in the length of the chord* for camber should be 1-1200th of the span, he would have hit it very nearly right, and his rule would have been entirely unexceptionable. Is it not possible that our tendency to mathematics has turned this rule into an absurdity and fastened it on our bridges for all these years?

Again, the camber, as figured under the old rule, is frequently excessive and unsightly, particularly where there are several long spans. It was for this reason that, in building the great bridge across the Ohio River, at Cincinnati, a few years ago, the engineers decided to use 1-1800th of the span as the amount of camber, and this amount was undoubtedly more than sufficient.

The Keystone Bridge Co. have a formula which accomplishes the same result as the rule given by Mr. Cooper—that is, it gives a constant increase to the length of the upper chord for the same span. Observe how much mathematics can be put into such a small thing.

The formula is as follows:

$$d = \text{versin} = \frac{L^2\, s}{c\, h}$$

in which s = stress in tons of 2,000 lbs.
L = span in feet.
h = depth of truss in feet.
$c = 900 + 8.4L$ for spans under 250 ft.
or $c = 3{,}000$ for spans 250 ft. and over.

This formula, it will be observed, gives only the versin; and it is necessary to figure from that the allowance to be made in the length of the chord; and all this mathematics to accomplish the result which can be obtained by stating that the top chord will have an additional length of one-eighth of an inch in every ten feet for camber.

As showing the results obtained in these different rules, the following table is appended:

Span.	Depth.	Cooper's Rule.		Keystone's Rule.		Old Rule.	
		Versed Sine.	I.*	Versed Sine.	I.*	Versed Sine.	I.*
Feet.	Feet.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
100	10	1.56	1.25	2.299	1.84	1.20	.960
100	15	.96	1.25	1.533	1.84	1.20	1.44
100	24	.65	1.25	.958	1.84	1.20	2.304
125	12	2.03	1.56	2.671	2.05	1.50	1.152
125	24	1.01	1.56	1.335	2.05	1.50	2.304
150	15	2.34	1.875	2.78	2.22	1.80	1.44
150	24	1.46	1.875	1.736	2.22	1.80	2.304
150	30	1.17	1.875	1.389	2.22	1.80	2.88
160	16	2.50	2.00	2.852	2.28	1.92	1.536
160	28	1.43	2.00	1.629	2.28	1.92	2.688
175	18	2.66	2.187	2.872	2.36	2.10	1.728
175	30	1.59	2.187	1.723	2.36	2.10	2.88
200	20	3.12	2.50	3.101	2.48	2.40	1.92
200	30	2.08	2.50	2.067	2.48	2.40	2.88
200	40	1.56	2.50	1.550	2.48	2.40	3.84

In the column headed "old rule," the versed sine in inches is taken $= 1.2 \times \frac{12 \times \text{span in feet}}{1200}$, which gives the gross camber.

The Keystone rule is believed to give the gross camber also, and Cooper's rule does so.

Keystone's formula clearly gives too much camber for the shorter spans, and is undesirable on that account, besides its other failings. The deficiencies of the old formula are clearly made apparent, showing too much camber for deep trusses and too little for low ones.

Mr. Cooper pays an entirely just tribute to our present positive knowledge of the capacity of our structures, obtained through systematic methods of testing, by which our factor of ignorance has been assigned to a back seat and removed from the specifications. It is undoubtedly true that our inductive methods in testing have not only proved our theories, but entitle us to place the highest confidence in the bridges which we are building at the present day.

The description of shop methods and practice is very clear, as is also the article devoted to erection, with its remarkable series of illustrations, taken from the Cairo Bridge, showing the daily progress made in erecting this great span of 519 ft., which was completely put up in five days.

* Note.—I = Increase in length of top chord.

The last article in the book, however, on "failure of bridges," is undoubtedly a fitting culmination to the entire book, and one which the author had in view from the outset.

Starting by characterizing the American type of bridge as a true evolution, the author has developed the facts of this evolution, with respect, not only to the materials used and the methods employed, but also to our system of designing and proportioning, and has thus laid most admirably the basis for the argument in reply to critics of the American Bridge *per se*. There can be no doubt that American bridges have been subject to indiscriminate criticisms in this respect from people who should know better. And the fact that this subject should have been presented before a foreign society by an American author has undoubtedly stirred up Mr. Cooper as well as many other American engineers. The author's analysis of these bridge failures and of the reasons for them is very forcible, and he is undoubtedly warranted in concluding that "it is a very gratuitous claim to assume that the bridge accidents on railroads in America are in any manner due to the accepted forms of our bridges, or that other forms of bridges would have given different results under the same circumstances." He convicts his opponents of careless deductions.

Entirely aside from the question of type, however, it is still true, as was said, we believe, at the Seabright meeting, that we must expect our bridges to stand, occasionally, the shocks of wrecks or the impact of derailed trains, and criticism of not a few bridges on this score is well advised. To the author's question, whether any one advocates the "designing and building of bridges to withstand the impact of a derailed train or the bursting effect of piling two trains on top of one another inside of the truss," we must answer, yes, that many people do and more should. Mr. Cooper recognizes this thing himself, by the use of a formula for the end posts of bridges, which gives them unusual weight, and, as he has stated in print, we think, is intended for just this purpose.

Any one who has been in the habit of examining existing bridges knows how many of them show the effects of derailed trains or of minor collisions; and if we build a bridge which may be expected to be good for one hundred years, we must take into consideration this sort of thing. The lightness of the web system of many of our bridges is, undoubtedly, to-day, their greatest defect; and the whimsical railroad manager who said he "was always afraid, in going over the bridges, that some fellow would stick his head out the window and knock the truss over," expresses the idea which these structures convey to the minds of many people.

While we may, therefore, resent the adverse criticisms of the American Bridge *per se*, and while we may look with pride on the skill and economy with which it is designed and built, we ought, nevertheless, to learn from our critics something on this very point which Mr. Cooper declines to consider.

There is one other point to which the author does not refer, and which, perhaps, is likely to receive more consideration hereafter than heretofore—that is, the artistic designing of bridge structures. Our manufacturers turn out many graceless structures, graceless in design and graceless in detail, and in the majority of structures this matter receives no consideration.

The Whipple Bridge lends itself very readily to artistic treatment, and is, if judiciously proportioned, a very graceful structure, especially so with the curved or broken chord now so generally used.

In looking to our future bridge-work, the question naturally arises, wherein will our bridges, ten years hence, differ from those we are now building? Presumably they will be a little heavier, although a majority of our railroads are now using heavy train loads of 4,000 lbs. to the foot; but we believe the real difference will exist in designing our bridges more with an idea of making them efficient machines to stand, not only the rolling loads, but the wear and tear of a heavy traffic and of a derailed train if necessary. They will also, doubtless, be handsomer in design and detail than they usually are.

Proceedings, Engineers' Club of Philadelphia, Vol. VIII, No. 3, July, 1891.

Yours truly,
Wilfred Lewis

Elected President January 10th, 1891, for the Fourteenth Year of the Club, A. D. 1891.

PROCEEDINGS

OF THE

ENGINEERS' CLUB OF PHILADELPHIA.

ORGANIZED DECEMBER 17, 1877.

NOTE.—The Club, as a body, is not responsible for the statements and opinions advanced in its publications.

Vol. VIII.] JULY, 1891. [No. 3.

OPENING ADDRESS

OF

WILFRED LEWIS, President,

ON TAKING THE CHAIR FOR 1891.

Presented January 10, 1891.

GENTLEMEN:—I highly appreciate the honor you have conferred upon me, and I thank you sincerely for the privilege of serving the Engineers' Club of Philadelphia as its President during the coming year. It is not without some diffidence, however, that I enter upon the duties of the office which my predecessors have filled with so much ability and credit, and in taking the helm from more skillful hands it is pleasant to feel the reassurance which you have given me in the selection of a strong and competent Board, some of whom have had large and fruitful experience in the direction of Club affairs.

Relying, as I do, on your co-operation in all that pertains to the prosperity and usefulness of the Club, I do not anticipate any squalls or rough weather that will require much seamanship on my part; but, if I am not mistaken, there is the other

possibility of drifting in a calm, that is more to be feared, and that will require more energy to avert. Our position among other societies and before the country at large is certainly a matter of pride, but we should not on that account falter in our progress, nor rest from our labors on the laurels we have won. We have abundant talent in our midst to expand indefinitely the prestige of our society as an engineering center.

Let us profit by our advantages, and determine this year to raise a breeze that will carry us farther than we ever went before.

Let us show our sister societies that, while Philadelphia is waking up to a realizing sense of the great destiny before her, her engineers are leaders in the van of progress.

Our membership is large and representative, but I am afraid not so communicative as it might be to advantage. We are too modest or too comfortable in this great city of homes to exert our latent strength, and a revival of some kind seems to be needed. Whether the proposed lunch after the adjournment of each meeting will be sufficiently effective in the promotion of sociability, remains to be seen. It will certainly do some good; but while "the encouragement of social intercourse among men of practical science" is a laudable object of our organization, "the advancement of engineering in its several branches, and the professional improvement of our members" claim equal shares of attention, and I trust they will not become secondary features in the good times to come.

XIV.

THE USE OF A PUMPING DREDGE BY THE NORFOLK COMPANY.

By John Graham, Jr., Active Member of the Club.

Read December 20, 1890.

The land upon which the city of Norfolk is built, and the surrounding country, is low and flat, averaging only about twelve feet above low-water mark.

The Elizabeth River, which constitutes the larger portion of the harbor of Norfolk, has several arms which reach out into the country and surround Norfolk almost on every side. These are usually shallow, having not more than three or four feet of water at low tide, but with a great depth of sediment, which is a mixture of mud and sand.

The growth of the city of Norfolk in late years has been considerable, and the available space for building purposes has been taken up to such an extent that it became necessary to seek other ground than that which was inclosed by the arms of the Elizabeth River. It is this fact which has induced The Norfolk Company to take up the development of a large tract of land, which, while within the city limits, is separated from the more thickly populated portion by Colley's Creek. To utilize this property the company is constructing a bridge and causeway across this creek, which together will be only four hundred feet in length, and will be made to resemble a street as much as possible, being designed on the general plan of the Girard Avenue Bridge across the Schuylkill in Philadelphia.

As the manufacturing and mercantile requirements are to be provided for on other sites, it is proposed to use this tract of land, about two hundred and fifty acres, for residences alone; to grade and pave the streets, to provide sewerage, water, gas and electric light, and to construct a large number of houses ready for occupancy in the best and most approved manner; in short, to provide, to a certain extent, a ready-made city, and, in doing so, to harmonize, as far as possible, the natural capabilities of the landscape with architectural construction.

The company has laid out the property in question in as attractive a manner as possible, and owing to the configuration of the ground, resembling very much that of Holland, the streets and parks have been laid out in imitation of the best features of some of the old Dutch towns.

A number of acres of the property of The Norfolk Company are low-lying and swampy, and, in order to be utilized, require filling to the level of the higher portions. In laying out the streets, it was necessary to place them upon as high an elevation as possible, therefore it was not feasible to obtain material for

filling upon the property itself or from the land in the vicinity. The material chiefly used at the present time around Norfolk for filling in low places is oyster shells, which at this time are expensive to purchase and costly to place in position. In order to obtain the material for filling, it was decided to dredge it from the bottom of the harbor and from Colley's and Smith's Creeks, which adjoin the property, and for this purpose a pumping dredge has been employed, and has now begun active operations.

While this machine has been in use for some time, I am inclined to believe that it is not generally well known; and while I hope to give a more minute description of it on a future occasion, I trust that the general account of its workings will not be uninteresting to the members of the Club. The dredge has been in use for some two or three years, and is, I understand, protected by several patents which have been obtained upon different portions of the machinery.

It has done a great deal of work at Oakland, Cal., and on a portion of the low ground on the Potomac Flats, near Washington, also at the town of Bridgeport, Conn., where it has been successfully employed in reclaiming a number of acres of previously useless swamp. Within the last four months it has reclaimed some twenty-seven acres of land for the Norfolk & Western Railroad Company at Lambert's Point, which has been raised from a depth of two or three feet below water to eight feet above high-water mark.

The dredge in question is a large and substantially constructed scow or float, in which is placed the necessary power to drive a large centrifugal pump.

The pump has a 20″ suction-pipe, which, being supplied with ball joints, is capable of following the movements of a carriage upon which it is mounted.

The carriage is placed at the end of the float overhanging the water, and has a lateral traverse of fifty feet.

The suction-pipe is provided with a telescopic arrangement which allows it to be raised or lowered when required. The foot of the suction-pipe takes a position immediately above a circular cutting-bar, in which are set a number of teeth.

The cutting-bar is revolved by a square shaft with gearing,

which is in turn operated by an auxiliary engine. The shaft and cutting-bar are also raised and lowered in harmony with the suction-pipe.

The discharge-pipe from the pump is also twenty inches in diameter, and is made up of sections of light wrought-iron pipe about eighteen feet long. These are laid on pontoons from the dredge to the shore, and thence can be laid along the surface of the ground for any reasonable distance to the point required to be filled. The joints of the discharge-pipe are usually made of rubber tubing, but ball joints are used where the angle is very great.

In operation, the telescopic suction-pipe and cutting-bar are lowered upon the bottom, and the revolving cutters throw the dislodged material into the suction-pipe, from which it is taken up by the pump and discharged upon the shore. A cut of one foot is made over the distance (fifty feet) traversed by the carriage, the suction-pipe and cutting-bar being lowered at each end of the traverse.

I have given above a short and simple description of a machine with which no doubt many members of the Club are familiar. It is more interesting for us to know what the dredge can do and what are the results of its work.

Of the material discharged, only an average of ten per cent. of solid matter is obtained.

It is, of course, necessary that the bottom of the stream to be dredged should be of such material as can be easily affected by the cutter.

The dredge is capable of cutting to a depth of twenty-six feet below the surface of the water, and practically all of the material dislodged is deposited upon the shore.

The method pursued in reclaiming waste ground is generally to inclose the desired portion by a wharf or bulkhead, using sheet-piling to make it reasonably tight. It is, however, perfectly feasible to throw up an embankment with an ordinary dredge. The material is then pumped in, the end of the discharge-pipe being placed at points considered most desirable. Naturally, the heavier material forms very quickly around the mouth of the discharge-pipe in a solid mass, that held by the water being carried to greater distances.

While I am informed that the work of the dredge at Oakland and on the Potomac Flats was extremely satisfactory, I have not examined the result attained and cannot speak of my own knowledge concerning it.

At Bridgeport, Conn., some sixty acres have been reclaimed during the present year, the work having been completed in April last. The ground was raised about ten feet and is now being laid out in streets. The material deposited was dredged from the bottom of the river, and consisted at the time of a mixture of mud and sand.

During the past few months, the Norfolk & Western Railroad Company, under the direction of the engineer in charge of the company's work, Mr. W. L. Keen, reclaimed some twenty-seven acres, which are between the Port Warden's line and the shore line immediately adjoining the great coal piers of the company at Lambert's Point. The ground here was raised to about six feet above high water; and although the work was begun as late as last June, tracks have been laid across the fill, over which heavy locomotives and cars are now running.

The object in this case was not so much to reclaim the land, which was practically valueless, being covered with only twenty inches of water at low tide, as to provide deep water in front of the piers and warehouses. A depth of twenty-eight feet was obtained, and the ground reclaimed is now valuable enough to more than pay for the cost of dredging. The material deposited was very much the same as that at Bridgeport.

The results of Mr. Keen's calculations show that, taking an average for one month, the dredge deposited four thousand cubic yards per day, of sixteen hours, of solid matter.

Mr. Keen is much pleased with the work of the dredge, and states that he had little or no trouble in maintaining his bulkhead and in placing the dredged material at any point desired. In some instances he deposited the material three thousand feet from the dredge.

On the other hand, The Norfolk Company desires the material for filling more than the necessity for depth of water, although the last will be of great value.

A timber bulkhead has been constructed along the front of the

property for more than a mile, and it is proposed to fill up the edges of the water front and the low-lying ground to the height of the general level.

Two of the arms of the Elizabeth River, Colley's and Tarrant's Creeks, it is intended to close and fill up altogether. It is expected that these shallows which are now valueless will, upon the satisfactory completion of the filling, be worth from ten to twenty thousand dollars per acre. The company has not been disappointed with the work of the dredge so far.

The advantages of this machine seem to be:

(1) Ability to transport material to a reasonable distance.

(2) Celerity in dredging and removing obstacles to navigation.

(3) Celerity in filling.

(4) Economy in removing and depositing the material.

XV.

CROWN BAR STAYS.

By G. R. Henderson, Active Member of the Club.

Read December 20, 1890.

Some years ago I had occasion to re-design the crown bar stay or link used in supporting the crown sheet of locomotive boilers. These links were attached at the ends by $\frac{7}{8}$-inch bolts in double shear. In order to get all parts of uniform strength, I proceeded as follows:

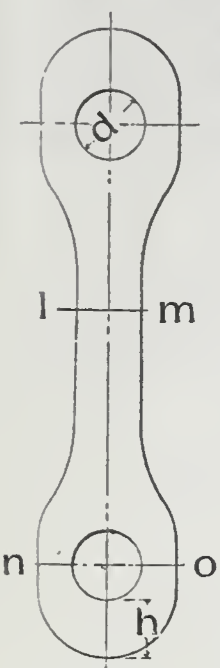
Let P=tensile force through stay.
f=factor of safety.
k=ultimate strength of material.
d=diameter of hole.
b=thickness of link.
h=depth back of eye.

The area through l–m* was made $= \frac{Pf}{k}$ also $h = \sqrt{\frac{3}{4} \cdot \frac{Pdf}{bk}}$

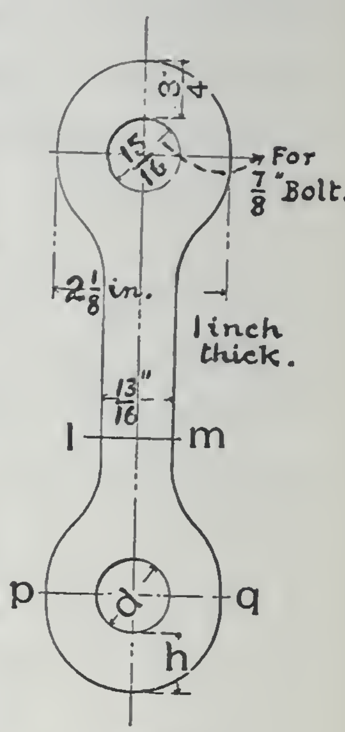
* See figures, next page.

The total area on line n–o was made $= \frac{Pf}{k}$, and several links were *forged*, as shown in sketch, and the holes drilled. These were then tested to destruction, and found satisfactory.

But when the links were made out of hammered iron, and punched out hot by a die under a steam hammer, the holes still being drilled afterward, it was found necessary to increase the amount of metal on line n–o, and therefore it was made in area $= \frac{3}{2}\ \frac{Pf}{k}$ as shown on the line p–q, the other dimensions remaining as before.



FORGED.



PUNCHED.

One dozen were made in this way as samples and tested, and proved to be of nearly uniform strength. The figures on the second sketch give the sizes actually used, and below will be found the results of the tests. $\frac{7}{8}$-inch bolts were passed through a plate on each side of link, and it was pulled in this manner.

TEST OF TWELVE LINKS.

No. 1—46,200 lbs.	.	Sheared bolt.
2—40,500 "	.	End of eye.
3—46,800 "	.	Sheared bolt.
4—45,400 "	.	In center of link.
5—47,800 "	.	Sheared bolt.
6—46,600 "	.	Sheared bolt.
7—47,100 "	.	In center of link.
8—48,900 "	.	Sheared bolt.
9—47,400 "	.	Sheared bolt, broke plate and cracked eye.
10—50,000 "	.	Sheared bolt and cracked eye.
11—49,000 "	.	In center of link.
12—45,400 "	.	In center of link.

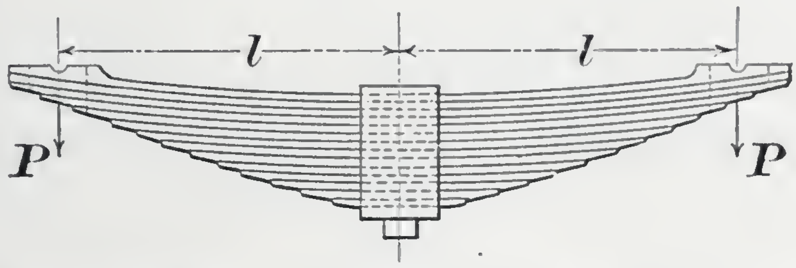
XVI.

FORMULÆ FOR THE DEFLECTION OF LOCOMOTIVE DRIVING SPRINGS.

By GEO. R. HENDERSON, Active Member of the Club.

Read January 17, 1891.

SOME years ago, I had occasion to examine quite thoroughly into the laws governing the deflection of locomotive springs. I



found the formula usually given in books to be incorrect, and so was led to discover, if possible, one which would give more accurate results.

The equation usually specified is:

$$\delta = \frac{6Pl^3}{Enbh^3} \quad . \; . \; . \; . \; (1)$$

where $\delta =$ deflection of spring, in inches.

$P = \frac{1}{2}$ the total load on the spring, in pounds.

$l = \frac{1}{2}$ the working span, in inches.

$E =$ modulus of elasticity of the steel.

$n =$ number of plates.

$b =$ breadth of plates, in inches.

$h =$ thickness of plates, in inches.

This will be recognized as the form for a beam of uniform strength, loaded at one end and supported at the other, and when the breadth varies as the distance from the load, and the thickness is constant.

This formula, however, supposes the width of the plate at the point of application of the load to be zero, and we all know that in locomotive springs, several plates extend a distance beyond the load, as in the figure. This will evidently stiffen the spring and diminish the deflection. If we supposed *all* the leaves of the spring to be of full length, *i. e.*, to extend beyond the load, we should have a beam of uniform section, and the formula

$$\delta = \frac{4Pl^3}{Enbh^3} \quad .\ .\ .\ .\ (2)$$

would then obtain. In other words, the deflection would then be but two-thirds of what it would be with leaves regularly shorter, and with the longest one reaching just to the point of application of the load. Now, for the ordinary spring, the value of δ will be between those given by the two formulæ, and will be nearer to the first, in proportion as there are fewer long leaves, *i. e.*, leaves extending beyond the point of application of the load.

Let φ = the number of long leaves; then

$$\delta = \frac{2Pl^3\,(3n - \varphi)}{En^2bh^3} \quad .\ .\ .\ .\ (3).$$

This formula will give:

$$\text{for } \varphi = o, \quad \delta = \frac{6Pl^3}{Enbh^3} \quad .\ .\ .\ .\ (1)$$

$$\text{for } \varphi = n, \quad \delta = \frac{4Pl^3}{Enbh_3} \quad .\ .\ .\ .\ (2)$$

which it evidently should, as mentioned above.

I have proved this formula in a number of cases, and found it to come remarkably close to actual test. In these calculations, E was taken at 30,000,000.

XVII.

NOTES ON STREET CLEANING AT WASHINGTON, D. C.*

By Conway B. Hunt, Active Member of the Club.

Read March 7, 1891.

The general interest which has lately been developed in the subject of the cleaning of the streets of our large cities constitutes, to a great extent, the apology for the presentation of this brief account of the organization and conduct of the street-cleaning department of the national capital.

It is true that the problem of clean streets in Washington is

* The lithographs accompanying this paper were kindly furnished by Gen'l L. P. Wright, the patentee of the sweeper illustrated.

free from many of the embarrassing complications frequently encountered; yet, on the other hand, there are counterbalancing conditions which should be estimated in comparing the results obtained here and elsewhere.

The climatic conditions of Washington are certainly favorable to the service. The generally smooth character of the roadway pavement, the preservation of which condition is contributed to by the absence of heavy drayage, affords self-evident facilities for easy and thorough sweeping. Not only are the sweepings more easily and thoroughly collectable from such a surface, but the tractive force necessary to move the large machines which are here used is reduced in a most considerable degree.

The impervious character of the very large portion of the swept area which consists of asphalt and coal-tar surface eliminates a large amount of that component of street-sweeping spoils which is derived from below the pavement by working up through the joints under the influence of traffic.

At the same time such a surface is cleaned by rainfalls of quite moderate amounts. The great width of the streets between building-lines affords exceptional opportunities for the action of high winds to remove large amounts of otherwise collectable material, while the extent of public and private parking presents the conditions of a large sodded area, upon which this matter can fall, and from which it is not dislodged by the same influence.

The general character of the city traffic is "*cleanly*," if such a term may be here employed with an obvious meaning; there is no tenement-house district, with all which that implies in other cities; the ordinances against the throwing or sweeping of refuse, papers, etc., into the streets are quite fairly enforced; and the question of the disposal of the dirt after its collection is limited to the choice of the most suitable from among several dumping-grounds within the city's limits. Finally, but by no means least among the favorable circumstances of the department and its work, is the absence of the element of improper political interference in its conduct.

On the other hand, the generally smooth roadways require a greater degree of cleanliness to escape criticism; the width of the streets, both as to roadway and between building-lines, creates a

large area, per foot front and per inhabitant, to be cleaned; and the notable arboreal wealth of the city adds, during the Fall, a very appreciable burden to the labors of the department.

The organization of the department consists of a superintendent in general charge, with the necessary assistants and inspectors to supervise the contract and day-labor work, and a hired force of horses, carts and laborers.

The superintendent reports directly to the Commissioners of the District, who are the analogue of the mayor in other cities. The operations of the department are confined to the sprinkling and cleaning of the improved and unimproved streets and alleys, the cleaning of the gutters and sidewalks, cutting of weeds and grass where necessary, etc., etc. The removal of ashes and garbage is not under this department, the former being left to the individual householders to accomplish at their own expense, while the latter is under the control of the health department, and is accomplished at a total cost of about $20,000 per annum ($20,000 in 1890, $22,000 in 1891).

The cleaning of the improved streets, to which the principal attention will be here given, is at present performed by contract at a rate of thirty-five cents per thousand square yards for each sweeping. This contract was made for a term of five years, and will expire June 30, 1892.

The cleaning of the improved alleys is carried on under another contract at the rate of thirty-three cents per thousand square yards for each sweeping, the term of the contract being two years to June 30, 1892.

The remaining items of work with which the department deals are carried on by hired labor, supplemented, to some extent, by the labor of the "chain-gang" from the District workhouse.

The extent of the paved streets of the city, which constitute the field for the operations of the street-sweeping contractor, is shown in the following table:

SUMMARY.

	Area in square yards.		Length in miles.	
Sheet asphalt, city,	956,794		43.2	
" " suburban,	13,693		0.57	
		970,487		43.77
Coal tar, city,		881,939		38.2
Asphalt block, city,		200,103		8.6
Total smooth pavement,		2,052,529		90.57
Granite block, city,	578,715		23.5	
" " suburban,	12,557		.5	
		591,272		24.0
Wood, city,		5,611		0.3
Cobble and blue rock, city,		452,614		11.5
Total wood and stone pavement,		1,049,497		35.8
Grand total of paved streets,		3,102,026		126.37

The remaining streets within the city, and which are cleaned by hired labor and the chain-gang, are summarized as follows:

	Area in square yards.	Length in miles.
Macadam,	270,320	8.0
Gravel,	591,418	29.4
Total,	861,738	37.4
Unimproved,	1,272,695	71.9

Attention is called to the area of smooth pavement within the city limits, as given in the first summary above, embracing asphalt, coal tar and asphalt block, and amounting to a total of 2,038,836 square yards.* It is stated that this exceeds the area of such pavements in any other city in the world. The table also affords the data for determining the average width between

* This, of course, does not include the 13,693 square yards "suburban" given in the summary.

curbs of the paved streets, which is nearly 42 feet (41.84+), ranging from 20 feet on a few short streets to 108 feet on Pennsylvania Avenue.

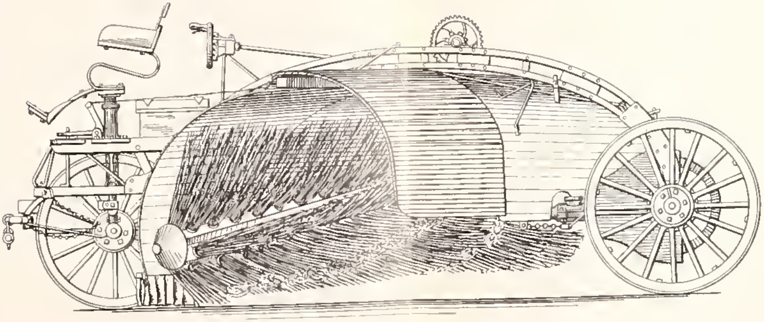
In the prosecution of his work, the street-sweeping contractor employs large sweeping machines drawn by four horses. Five each of two different kinds are used, the Wright and the Filbert (the former of which will be understood from the prints herewith).

There seems to be a consensus of opinion that the Wright is a thoroughly effective machine. Its total weight is 4,500 pounds; the broom is twelve feet long, set aslant the carriage so as to sweep a nine-foot swath; the broom and its shaft weigh 650 pounds and are suspended at a single point, thus allowing automatic accommodation for inequalities. The pressure of the broom is thus made uniform throughout the length, and its intensity is regulated by raising or lowering it by means of gearing operated by the hand-wheel shown behind the driver's seat. The broom itself requires renewal about once a week, at a cost of $4.80, under the service it performs here. It will be understood that during the progress of the machine the cylindrical broom is revolved by gearing driven by the wheels, thus sweeping the dirt successively forward and sideways toward the right until it escapes from the action of the brushes, and forms a windrow on the right-hand side. The following machine includes this windrow on its left-hand and carries it forward and still to the right in a similar way. Thus the half width of a street from the center to the curb is covered by a number of machines (the number being dependent on the roadway width), which collect the dirt into the gutters, the other half of the street being similarly swept on the return trip. Behind the machines follows a force of hoe-, broom- and shovel-men, who convert the gutter windrow into a succession of piles of dirt and then place these in carts to be hauled to the dump.

The sweeping is done by night, except when the contrary is specifically authorized for some such reason as cold weather preventing sprinkling after dark without freezing, etc.

The paved area of the city is divided among six routes, as shown in the schedules transmitted. These routes are swept in succession,

Fig. 1.



WRIGHT'S STREET-SWEEPING MACHINE.

Fig. 2.

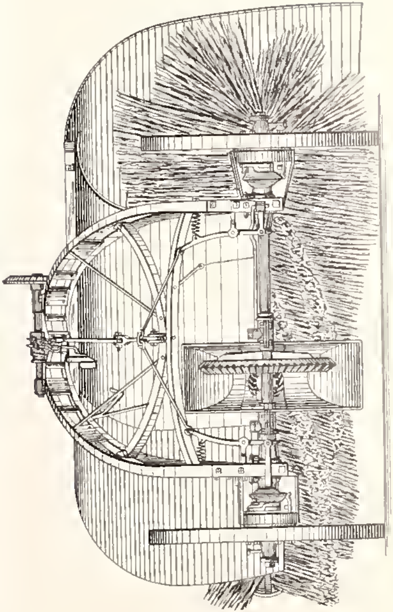


Fig. 3.

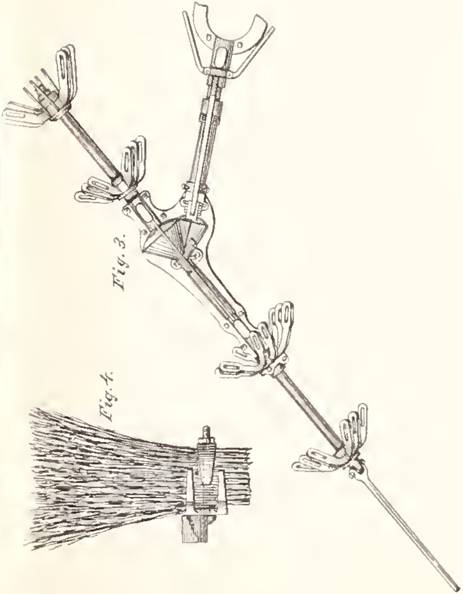


Fig. 4.

WRIGHT'S STREET-SWEEPING MACHINE

one each night. Certain streets in the heart of the city are common to all of these schedules and thus receive daily sweeping; others are common to three different routes, and yet others to two, and are thus swept a corresponding number of times weekly; while those found on only a single one of these lists are swept but once in the week. Streets are very frequently omitted from, or added to, the printed schedule used on any particular date, in accordance with the varying exigencies that arise. Such variations in the route to be swept are determined each day by the superintendent of the department.

The amount of material removed from the streets averages one cart-load (of one and a half cubic yards) per sweeping to every 3,000 square yards of area swept. Before sweeping a route it is sprinkled by the contractor at his own expense. In estimating the area swept each day, those intersections of streets which are gone over twice by reason of their being common to two swept streets, are paid for but once. The average force employed by the contractor in his work, besides the ten large sweepers, is four sprinkling-carts, 40 to 50 broom-, hoe- and shovel-men and 30 to 35 carts. The maximum force here named will clean 900,000 square yards of pavement in twelve hours. The removal of snow and ice from the streets is done by the contractor at a cost of force account plus ten per cent.; but fallen leaves, a large item in the Fall, are gathered and removed by the contractor at his own expense. Snow and ice removal cost $814 the past winter and nothing for the preceding one. The most valuable portions of the collected material for fertilizing purposes are carried to the wharves and loaded on scows for transportation. The balance goes direct to the various established dumping-grounds.

The appropriation for the department for the fiscal year ending June 30, 1890, was $85,000, which was expended as follows:

		Per cent.
On improved streets,	$57,761	68
On improved alleys,	4,195	5
On unimproved streets and alleys, snow and ice, etc.,	16,895	20
In salaries,	6,142	7
	$84,993	100

The appropriation for the present fiscal year of 1891 is $100,-000, and for the year 1892, $115,000; and every indication points to a percentage allotment of these sums practically the same as the one above given.

The service is effective by common repute, as is evidenced by the fact that during the past sixteen months but two hundred and ten complaints of all kinds have been made, the great majority being alley cases.

In the appropriation of moneys for the expenses of the District of Columbia, Congress has provided that one-half shall be charged against the people of the District, to be raised by taxes, and the other half borne by the general government, as holder of one-half the real estate in the city. Thus, practically, the street-cleaning department for the present year burdens the taxpayers to the extent of $50,000, which is certainly a cheap service. This is at the rate of 21 cents per capita per annum.

XVIII.

EXPERIMENTS ON THE DISCHARGE OF STEAM THROUGH ORIFICES.

By Strickland L. Kneass, Active Member of the Club.

Read March 21, 1891.

The laws governing the internal condition of an escaping jet of steam have been very little studied, and the few investigators who have written upon the subject have regarded it almost entirely from a theoretical standpoint. During the early part of 1887, a series of experiments were commenced at the works of William Sellers & Co., Incp., to obtain some data upon the subject, but owing to various interruptions the results were not tabulated, nor experiments completed, until the latter part of 1890. The object was to determine, as accurately as possible, by actual tests, the behavior of steam within a discharging nozzle, and the extent to which the terminal velocity is affected by changes in the proportion of the tube.

In order to obtain from an inelastic fluid, such as water, the maximum discharge in a given interval of time, attention was drawn, many years ago, to the advantages gained by a correct proportioning of the curves of approach and recession, in order that the transfer of the energy of the liquid from pressure to velocity, and from velocity to pressure, should be accomplished with the least possible loss. For this purpose the arc of approach to the minimum diameter was made in the shape of the vena-contracta, while from that point outward the tube diverged in easy curves to bring the fluid to rest without shock or impact. The advantageous effect of a divergent taper upon the discharge of elastic fluid is of more recent discovery and has not yet received much careful investigation. Although the object of these experiments was not so much to determine the best shape for maximum discharge in a unit of time, as to obtain the highest possible velocity from the steam, yet a divergent taper was so obviously suited to the efficient use of an expanding fluid, that the trend of these experiments was in that direction.

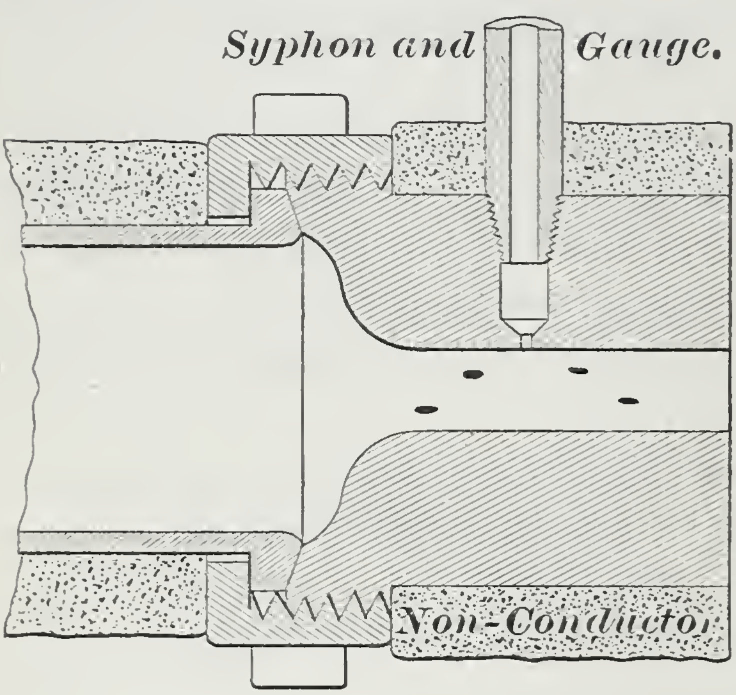
The problem, therefore, was to find the shape of tube that would give maximum velocity of discharge to the molecules of steam, under given initial and terminal pressures, assuming that no heat was received or given out by the steam during its passage through the tube.

The apparatus (Figs. 1 to 5, see plate) consisted of a brass nozzle of 8 mm. (.31496 inch) internal diameter at throat, and 34 mm. (1.34 inches) long. Although the diameter at the throat remained the same during all the experiments, the other diameters were varied. The tube was connected by a 2-inch pipe, carefully lagged with non-conducting material, to the steam main of a Galloway boiler capable of carrying 150 pounds to the square inch. Drip pipes were placed at points where water might collect, and great care was exercised to obtain perfect dryness of steam. In every case the main valve was opened, and steam allowed to blow through the nozzle for some time before observations were taken.

Now, in order to determine the velocity of discharge, it becomes necessary to know as far as possible the condition of the steam at the instant it leaves the tube. As the steam approaches the

nozzle with a very low velocity, and as the percentage of water in the steam is very small, we can confine ourselves entirely to the behavior of the steam after it reaches the minimum diameter.

In traversing the nozzle, the steam expands adiabatically, *i. e.*, without addition or subtraction of heat, and the relation of volume to pressure in all points of the tube will follow the law of adiabatic expansion. Under these conditions the volume is a function of the pressure, and if we can determine the pressure of the issuing steam at various points of its course, we can obtain therefrom the volume and the velocity. In order to determine these pressures, the nozzle was arranged with seven small holes,* drilled equal distances apart, commencing at the point where the curve of approach becomes tangent to the cylindrical barrel of the tube.



Each of these apertures had gauge connections at the outer end, and these were closed by plugs when not in use. These holes were very small when compared with the bore of the tube, yet of sufficient area to give correct readings on the gauge.

Another device was employed for determining the internal pressures of the jet *beyond* the end of the nozzle, and was chiefly used for that purpose. A small, sliding copper tube was placed concentric with the axis of the discharging nozzle; and by means of a small hole near the end of the tube and normal to its axis, the pressure was indicated upon a gauge placed back of the steam chamber. The end of the tube was closed at the discharging end by a long taper plug, in order to avoid the influence of the contraction at the extremity; and, by varying the position of the

* The positions of these holes are represented by the seven dotted and numbered vertical lines in Figs. 1 to 5.

tube, the pressure could be determined at any desired point. This arrangement had the advantage of placing the aperture normal to the line of discharge, and independent of the shape of the nozzle. There is, however, a slight change in the relation of the areas of different sections of a taper nozzle when reduced by a central cylinder, and to compensate for this the experiments with this device were made with a nozzle of proportionately larger diameter, having the same area of discharge and approximately the same relation of parts as the other tubes.

Both of these methods were used for determining the internal pressure of the jet at different points in the tube; and if the steam-weight were constant during expansion, the calculation of the velocity at any point would require simply to determine the volume corresponding to each observed pressure, multiply by the weight of steam discharged per second, and divide by the area of the cross-section of the tube in square feet, and the result would be the velocity in feet per second. But this would not be absolutely correct, because for every increment of expansion, a certain portion of the steam must give up its heat and condense, thus decreasing the steam weight and increasing the percentage of water. This formula would give too high results, and would have to be corrected at every point by the proportion of steam condensed.

Where the weight of discharge is not known, another method suggests itself, in which the work of expanding steam is calculated by plotting the observed pressure and volume of a unit weight, thus forming a card that indicates the energy producing the velocity of the steam. The curve AB* approaching a true adiabatic curve as the efficiency of the nozzle increases, the velocity may then be expressed thus:

$$V = 8.1 \sqrt{U},$$

where U is the work done by unit weight of steam, and represented by the area of the card. This formula will give the velocity at any point of the tube by limiting the extremities of the card to the points of the tube under discussion. This method was used in calculating the velocities shown in the diagram and is the sim-

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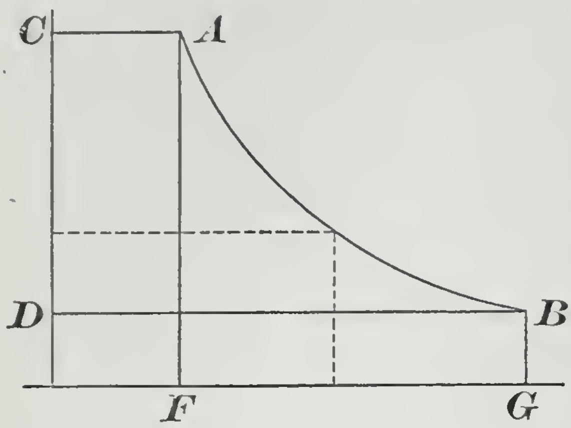
* See figure on next page.

plest method of comparison. The slight variation from the hyberbolic curve due to the polygonal form of the card will account for



the difference of some of the velocities from Rankine's formula. The variation in the form of standard formulæ is simply due to the methods of finding this value U, some depending upon the total quantity of effective heat in the steam, and others determining the work done from the area of the adiabatic curve between initial and terminal pressures.

The Experiments.

The apparatus being set in place, the steam was turned on and allowed to discharge freely into the atmosphere for some time before the experiment was commenced. Carefully-tested gauges were placed upon the small holes penetrating the tube, and observations were taken at these different points. The initial pressures were varied from 30 to 120 pounds gauge pressure, and the effect of the shape of the tube upon the discharging jet will be apparent from the diagrams.

The cylindrical nozzle, Fig. 1, was first tested, and the line joining observed pressures was plotted, showing a curve of gradually decreasing pressure, steeper at high pressure than at low. The pressure at the first hole bears nearly a constant relation to the initial pressure, while the ratio of the terminal to initial pressures falls slightly as the initial pressure decreases.

Initial Steam Pressure.	Ratio of Throat Pressure to Initial Pressure.	Ratio of Terminal Pressure to Initial Pressure.
p.	$\frac{p_1}{p}$	$\frac{p_2}{p}$
120	0.700	0.585
90	0.699	0.543
60	0.666	0.533
30	0.666	0.533
20	0.657	0.529

The action of the steam in this nozzle and the cause of its in-

efficiency are apparent from the diagram. Taking, for example, the 120-pound line, we find that while traversing the nozzle the pressure is reduced only from 80 pounds to 64 pounds and is discharged at that pressure into the atmosphere, losing nearly 66 per cent. of its velocity-producing energy. At 60 pounds initial pressure we notice that the velocity line (upper diagram) is a little higher than at 120 pounds.

With the next nozzle used, Fig. 2, the diameter of the throat was precisely the same, but instead of a cylindrical barrel, the discharging end was made in a diverging flare, increasing in a straight taper of 1 in 10 in diameter. The pressure in the throat now falls to about $\frac{6}{10}$ of the initial, and is very nearly the same as the terminal pressure in the cylindrical tube. We notice now that with high initial pressure the expansion approaches more nearly the hyperbolic curve and discharges very close to the atmospheric line, while the 60-pound curve falls even into vacuum lines and issues from the tube in a jet that contracts to a smaller diameter than that of the orifice. This phenomenon occurs with the 30-pound and 20-pound lines within the confines of the nozzle, and the pressure at the mouth is greater than that at the fifth orifice. This shows that for these lower pressures there is a loss of efficiency in going beyond this point of maximum expansion, and that the discharging jet would have higher terminal velocity if the tube were made shorter. A fixed relation, however, exists between the curve of expansion and the curve of velocity; and the nozzle that gives the lowest terminal pressure with the minimum area of discharge must necessarily give the highest velocity.

This may be noticed in the 1 in 5 tube, Fig. 4, where the curve of expansion for initial pressure of 120 pounds drops evenly down from 58 pounds at the first orifice to 3 inches vacuum at the seventh, without break or re-entrant angles, while the velocity reaches 2,975 feet per second. This same tube, with initial pressure at 90 pounds, gives a maximum velocity of 2,867 feet per second, while the steam is expanded to 9 inches vacuum. It also shows that for lower pressures it would be more efficient if made shorter, so that the point of highest velocity should be coincident with the terminus of the tube. A curve of pressures extended

beyond the end of a short nozzle shows that when the steam expands within a nozzle to a lower pressure than 15 pounds absolute, a contraction of the jet after leaving the tube is produced by the pressure of the atmosphere.

An experiment with the 1 in 10 tube, Fig. 2, before and after reaming the lower half with steeper tapers, showed that such reaming produced no effect upon the steam discharge of the upper half, and the curves of velocity and pressure are identical in the upper end of both tubes. The experiment has also been tried, of gradually shortening a tube by cutting sections off the lower end, and it was found that the pressures higher up were not affected in any way by the alteration.

In the calculation of the velocity of discharge there has been assumed the fact that the law of adiabatical expansion will cover the steam during its passage through the tube; that is, that the expansion of the steam is perfectly free, and that there is no superheating within the tube except a small amount due to friction, and that the necessary energy to produce the increase in velocity is obtained from the portion of steam condensed. As the quantity of heat radiated from the tube was very small, there must have been a certain percentage transferred from the upper part to the lower, so that the heat lost at the earlier part of discharge would reappear at the latter.

The velocity curves shown in the diagrams indicate very clearly the rapid rise in velocity as the potential energy of the fluid is changed to kinetic; and although the maximum reached in different tubes varies considerably, yet in most cases the velocity in the throat is practically the same. There may be mentioned in this connection a curious and well-established fact that the weight of discharge of elastic fluid from a given orifice is constant as long as the counter-pressure does not exceed about one-half the initial pressure; for example, the weight of steam discharged per second from a boiler at 120 pounds into a vacuum would be the same as that discharged against 56 pounds counter-pressure. If, however, the counter-pressure rise above 56 pounds, the weight discharged is reduced; so that if it be possible to lower the tension in the throat of the tube to 53 per cent. of the initial pressure, the results will approach even closer to the theoretical values.

The following table shows the variation of the ratio $\left(\frac{p_1}{p}\right)$ of throat pressure to initial pressure, with different initial pressures and different forms of tube.

RATIO $\left(\frac{p_1}{p}\right)$ OF THROAT PRESSURE TO INITIAL PRESSURE.

Initial Gauge Pressure, p lbs. per sq. in.	Taper of Nozzle.					
	Cylindrical Fig. 1.	1 in 10. Fig. 2.	1 in 6. Fig. 3.	1 in 6 and 1 in 10.	1 in 5. Fig. 4.	Special Curve. Fig. 5.
p	$\frac{p_1}{p}$	$\frac{p_1}{p}$	$\frac{p_1}{p}$	$\frac{p_1}{p}$	$\frac{p_1}{p}$	$\frac{p_1}{p}$
120	.703	.610	.606	.608	.539	.517
90	.689	.589	.582	.589	.498	.520
60	.665	.558	.558	.560	.501	.508
30	.664	.552	.541	.552		.507
20	.654	.524	.553	.520	.430	
10	.676	.510	.545	.506?	.496	

When expanding from 120 pounds to the atmospheric pressure, we find, from Rankine's formula, the maximum velocity attainable to be

$$V = \sqrt{\frac{2g\gamma}{\gamma - 1} \frac{p_0 v_0 \tau.}{\tau_0} \left[1 - \left(\frac{p_1}{p}\right)^{\frac{\gamma-1}{\gamma}}\right]};$$

from which, if we take $p = 135$ pounds and $p_1 = 14.69$ pounds, we shall have $V = 2{,}972$ feet per second, which should be closely approximated by the most efficient tube.

In all the straight taper nozzles there is one defect that was not noticed at first, viz.: the loss of energy due to fluid friction, owing to changes in velocity. It would seem to be true that these changes in velocity should cause less loss and internal friction if the acceleration of the jet be made uniform. A tube such as that shown in Fig. 5, giving a constant acceleration was designed in order to secure this result. The shape is difficult to manufacture, but the results that have been attained seem to prove the superiority of this type over the other nozzles used, the velocity in this case approaching very close to that of the formula given above, and reaching at the terminal point a speed of 2,890 feet per second. In designing this nozzle, the pressure

at the throat of the tube was assumed at its lowest theoretical value, and the terminal velocity at the highest attainable in expanding from 120 pounds pressure to that of atmosphere. The tube was divided into seven parts and the acceleration calculated. Then, in order to divide the work evenly, the expansion was made uniform, and from these data the area of the tube at each given section was determined.

The results as found are plotted in Fig. 5, and approach closely to the theoretical values. The terminal velocity demonstrates a high efficiency for this tube, and the results for different pressures have proved very satisfactory.

The Diagram.

In the accompanying plate, Figs. 1 to 5 show sections of the principal tubes used in the experiments, and illustrate graphically the pressure and velocity of the steam during discharge. On the upper half, lines are drawn connecting the calculated velocities at points corresponding to the observed pressures. These lines should approximate regular curves, whose shape will depend upon the form of the tube and the pressure of the steam; and the actual irregularities indicate possible errors in the experiments, or points at which the continuity of expansion of the steam is broken and where the condition of the jet is that of unstable equilibrium. This is especially noticeable with pressures below 60 pounds; and it is only in the case of the cylindrical nozzle that at these pressures the jet completely fills the tube. The pressure curves are, in general, very regular, and approach the hyperbolic shape due to adiabatic expansion.

The velocity lines are even more suggestive than the pressure curves; for it will be noticed at once that, notwithstanding the differences in pressure, the velocity curves for 120 and 30 pounds initial pressure fall close together. In the special nozzle, Fig. 5, the velocity curves are almost identical for all pressures, so long as the expansion is continuous; and for this nozzle it may be said that the velocities at any given point are practically the same for all pressures used. If we consider the formula given by Rankine for velocity of steam, we will see that there is but slight variation from constant velocity under these conditions.

In the form in which it is given on page 183,* we see that fordry saturated steam, and for a constant value of $\frac{p_1}{p}$, the velocity will depend only upon the absolute temperature of the steam in its initial condition, and will give, therefore, a lower velocity for 30 than for 120 pounds; but it will be seen from the table of ratios of $\frac{p_1}{p}$ given on page 183, that for the minimum diameter of the tubes this value decreases with the initial pressure, and consequently increases the value of the term $\left[1 - \left(\frac{p_1}{p}\right)^{\frac{\gamma-1}{\gamma}}\right]$. In the case of the fourth section of the special nozzle, we have, for the value of

$$\tau\left[1 - \left(\frac{p_1}{p}\right)^{\frac{\gamma-1}{\gamma}}\right]$$

Initial Gauge Pressure.	Calculated from Thermo. Eq.	From Experiments.
120 lbs. per sq. inch.	11.86	11.86
90 " "	11.74	11.79
60 " "	11.60	11.77
30 " "	11.36	11.81

and the velocities will be in proportion to these figures. This shows a maximum theoretical difference of 4 per cent. between the velocity at 30 and 120 pounds. In the right-hand column are given the same ratios for the actual velocity of the discharging jet, and these seem to be more nearly constant, as the widest range is less than 1 per cent. It may be that there are certain conditions that cause this variation from the thermodynamic equation, conditions that actually make the velocity of the steam practically constant at all pressures. A change in the percentage of water in the steam, or a transfer of heat from the upper part of the tube to the lower, might account for a part of this difference. If the discharge of the steam were perfectly free and unconfined, there might be still further change in these ratios, as the terms in the parentheses in Rankine's equation would have still lower value.

The following table gives the actual velocity of the steam at the different sections of the tubes, and corresponds with the velocity curves plotted on the upper part of the diagram:

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* $V = \sqrt{\frac{2g\gamma}{\gamma - 1} \cdot \frac{p_0 v_0 \tau}{\tau_0}\left[1 - \left(\frac{p_1}{p}\right)^{\frac{\gamma-1}{\gamma}}\right]}$

Shape of Tube.	Initial Pressure (Gauge).	Velocity in Feet per Second.						
		Sections.						
		1	2	3	4	5	6	7
Cylindrical. Fig. 1.	120	1195	1252	1349	1368	1400	1464	1500
	60	1261	1291	1416	1445	1513	1560	1589
Straight taper, 1 in 10. Fig. 2.	120	1386	1799	2081	2250	2389	2495	2668
	90	1541	1946	2246	2378	2166	2601	2707
	60	1532	1882	2168	2272	2384	2459	2601
	30	1517	1926	2047	2235	2341	2235	2143
Straight taper, 1 in 6. Fig. 3.	120	1400	1927	2328	2500	2669	2765	2855
	90	1483	1822	2312	2457	2664	2707	2867
	60	1310?	1960	2389	2476	2484	2712	2652
	30	1513	1927	2119	2380	2479	2158	2139
Straight taper, 1 in 5. Fig. 4.	120	1504	2091	2466	2632	2801	2910	2975
	90	1710?	2062	2420	2526	2646	2768	2827
	60	1638	2071	2447	2483	2678	2755	2505
	30	1599	2042	2408	2216	2235	2206	2158
Special curve, uniform acceleration. Fig. 5.	120	1662	2065	2272	2476	2657	2746	2890
	90	1681	2069	2267	2462	2563	2663	2823
	60	1696	2023	2216	2457	2592	2717	2881
	30	1626	1956	2187	2466	2331	2206	2148
Mean for Fig. 5. (continuous expansion)		1666	2028	2235	2465	2604	2708	2864

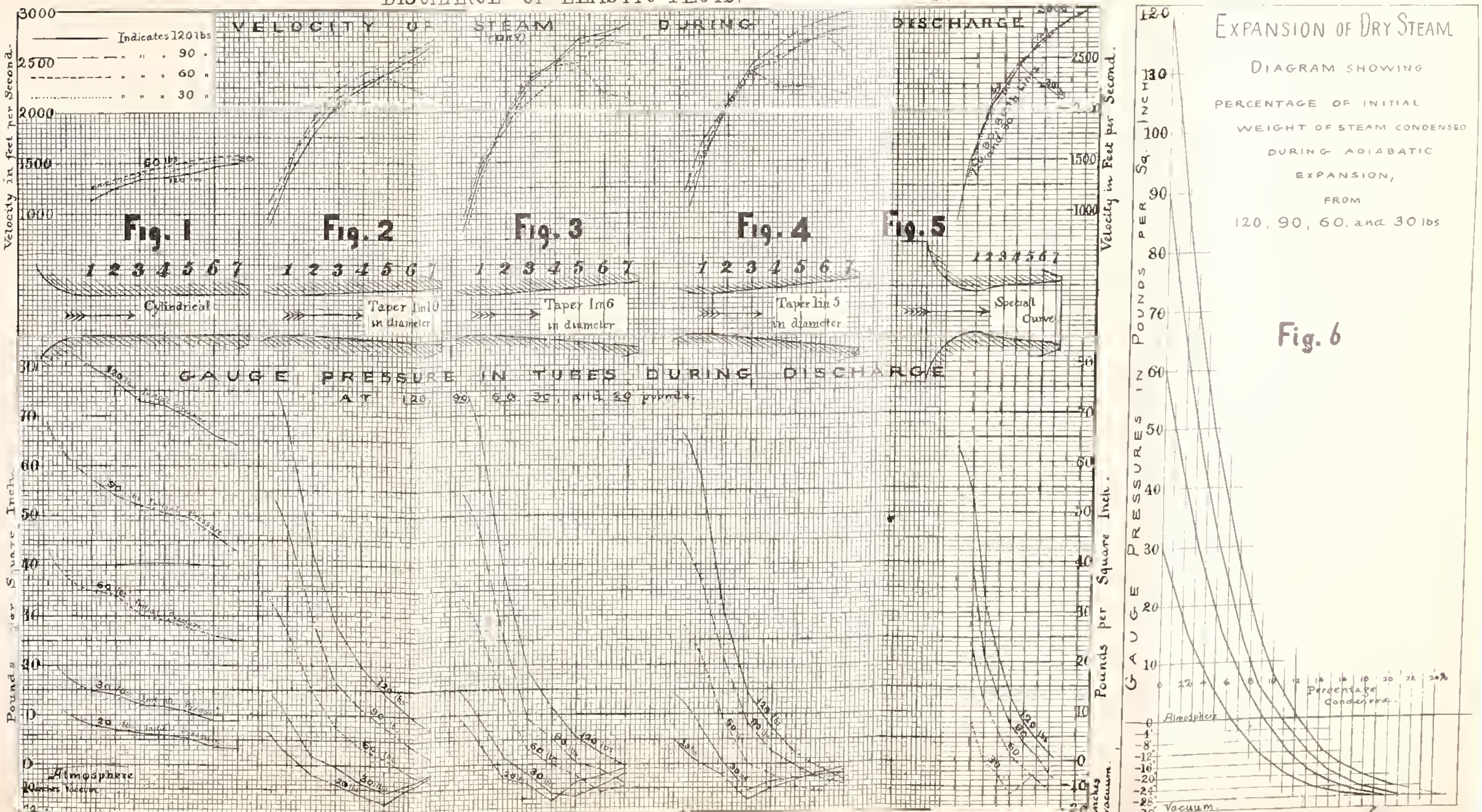
It will be seen from this that the variation of the velocity from a constant value for all the above pressures is exceedingly small; and allowing for the unavoidable percentage of error in experimental work of this kind, the velocity may be said to be constant at any given section of a tube for all ordinary pressures. The action of the steam within the special nozzle approaches most nearly the condition of free discharge, so that the velocities at Section 1 will apply to an aperture in a thin plate or short cylindrical tube.

If steam were a perfect gas that followed the law, $pv = p_1v_1$, it could easily be shown from theoretical considerations that the velocity of discharge must be a constant for all pressures, so long as the initial is more than twice the final pressure; but the equation for steam expressing the relation of the adiabatic curve is

$$pv^\gamma = p_1v_1{}^\gamma,$$

and the simple relations of velocity and pressure will not hold.

DISCHARGE OF ELASTIC FLUID.



For all practical purposes, however, the velocity may be considered constant, as has been already demonstrated, and a simple formula for determining the weight of steam discharged through an orifice in a given interval of time can be deduced, which is more convenient to apply than the usual thermodynamic equation. It is based upon the assumption of constant velocity of discharge, and we have

$$W = 6.19\,SD,$$

where W = weight in pounds discharged per second, S = area of orifice in square inches, D = weight of one cubic foot of the steam in its initial condition. This will apply to all ordinary cases where the ratio of final to initial pressure does not exceed $\frac{6}{10}$.

The curves in the diagram on the right, Fig. 6, indicate the percentage of total weight of steam condensed, for different degrees of expansion. The lines are drawn for 120, 90, 60 and 30 pounds initial pressure, and the intermediate pressures can easily be interpolated. The steam is supposed to be dry and saturated, and to expand without addition or subtraction of heat. The formula used was

$$x_1 = \left(\tau - \tau_1 + \frac{rx}{T}\right)\frac{T_1}{r_1};$$

where x_1 = percentage of uncondensed steam after expansion to lower pressure;

T and T_1 = absolute temperatures;

r and r_1 = latent heat;

τ and τ_1 = the entropy or heat-weight of the liquid.

XIX.

ECONOMICAL REVIEW OF ALABAMA COAL FIELDS.

By C. R. Claghorn, Active Member of the Club.

Read April 4, 1891.

The coal-producing area of Alabama lies in three separate fields, known as the Warrior, Cahaba and Coosa fields, these names being derived from the rivers which drain their respective areas.

The Alabama coal fields form a prolongation and the southern terminus of the great Appalachian coal field; and the measures are directly traceable from Alabama, through Tennessee, northeastward. Following the rule of the measures affected by the Appalachian mountain disturbance, their strike is from northeast to southwest, in Alabama, at the same time showing a general pitch to the southwest. Local geological disturbances, and subsequent erosion, have divided the once entire field into three separate areas, as before indicated, which lie parallel to one another, separated by comparatively narrow valleys of the older formations.

The Warrior field is much the largest of the three, having an estimated area of 7,810 square miles. In general form it is a shallow synclinal, the axis of which is nearest to the southeastern outcrop, thereby causing the northwest dips to be sharp to the axis, with much less pronounced (in fact almost flat) southeast dips. Several minor flexures occur in the Warrior basin, being most pronounced in the northeast area, where they somewhat affect its outline; but these flexures die out and disappear before they reach the middle or main body of the field.

Conservative reports indicate the existence of seven seams of coal of workable thickness (three feet and upward) over a considerable area of the field, the upper seams of course being the more limited. Other coal seams exist and may be found to be of local importance at many points. The coal seams show a tendency to thin from the southeast outcrop toward the northwest, at the same time thickening along the strike toward the southwest, so that it would appear that a line of *average* thickness might be drawn diagonally across the field.

Another feature of the Warrior field is the noticeable increase of hardness in the coals toward the northwest. All coal mined along the southeast outcrop is very soft and friable, suitable only for steam and coking purposes. The harder coals, suited to preliminary preparation by screening for steam and domestic use, are found only in the interior of the field and toward the northwest edge.

The chemical composition of the Warrior coals remains about the same over the entire field, and shows no sign of altering with

the physical character. All the coals so far found or worked may be classed as medium bituminous. No very dry coals, high in fixed carbon, have been found ; nor, on the other hand, have gas coals, rich in volatile hydrocarbons. Carbon runs from 55 per cent. to 63 per cent.; volatile matter from 28 per cent. to 34 per cent.; ash from 5 per cent. to 10 per cent.; and sulphur from 0.5 per cent. to 2 per cent. The moisture in all Alabama coals is quite low. Many analyses and individual samples may show results outside the above limits; but from personal experience I should say that these limits are wide enough to include all Warrior field coals in commercial lots. Notwithstanding a seemingly unchanged chemical composition throughout the field (by unchanged I mean in a noticeable and regular degree), the coking properties grow feeble toward the northwest and appear to decrease with the increase of hardness. This fact, however, is more particularly noticeable in the lower seams that cover the greatest area.

From the foregoing it may be deduced that the best coking coals come from a strip along the southeast edge of the basin ; that the best lump and domestic fuels, and coals best suited for handling in transport, will come from the interior.

Owing to the pitch of the Warrior field (a similar pitch being exhibited in the Coosa and Cahaba fields), the thicker seams, found more in the middle and upper part of the coal measure proper, only underlie that part of the field lying to the west and northwest of Birmingham and west of the Louisville and Nashville Railroad, running north across the field. Such coals as are found north and northeast of Birmingham and east of this line of railway belong to the lower measures. While in many cases marketable, they are thin and expensive to mine, and in competition with other coals may either be crowded out of the markets or yield a very small margin of profit.

The Cahaba field, with an area of about 435 square miles, lies next southeast of the Warrior field. It is long and narrow, somewhat spoon-shaped, bulging out toward its southwest extremity. The geological disturbances of this field are much more numerous than in either the Warrior or Coosa fields. Several minor faults extend through the field, with a northeast strike along the axis, and the whole of the southeast edge of the basin is cut off by a

large fault estimated at 10,000 feet, by which the Silurian rocks are brought up against the coal measures. This fault cuts out all the northwest dips of the basin, so that all the general dips within the field are toward the southeast, except where local disturbances occur, and therefore there is no southeast crop. The pitch of the basin is toward the southwest along the strike, though to a less degree than that exhibited in the Warrior field. A general thickening of the measures is also noticeable in this direction.

The coals of the Cahaba field have been divided into two groups, separated by several thousand feet of barren measures. The *upper* or *Montevallo group*, containing four to five seams, three being probably of workable thickness, exists only in the southern part of the field, and on account of the high degree of pitch and broken and disturbed condition of the measures, is of small importance except in possibly one or two small local basins.

The *lower* or *Cahaba River group* contains some seventeen seams, of which seven may be considered workable. The general opinion has been held that the coals of the spoon-handle or upper field are worthless on account of their dirty and slaty condition, and also on account of the tendency to thin in that direction.

The coals of the Cahaba field are strong, hard coals; in general compact, and exhibiting but little cubical fracture. They do not weather, and stand handling well, and are therefore adapted to long transport and transfer like the interior Warrior field coals. They are also noticeably free from slate partings, which are quite prevalent in the thicker coals of the Warrior field. They are quite regular in chemical composition, showing from 30 per cent. to 33 per cent. of volatile matter; 60 per cent. to 63 per cent. of carbon; 3 per cent. to 6 per cent. ash, and from 1 per cent to 2 per cent. sulphur. The field, as at present developed, produces the best "all-around" coal in Alabama. It makes an excellent coke, is a good domestic and steam coal, and its physical characteristics are such that it bears transportation and handling well.

But little is known of the *Coosa field*, with an area of about 415 square miles, beyond the fact that it resembles the Cahaba field geologically, though the dips are much flatter. It contains two or three workable seams of good coking and steam coal, but very soft in texture and unfit for handling. There are only

two operations in the field, at St. Clair and Ragland, which, in point of production, are of minor importance.

In reviewing the Alabama fields from an economical standpoint, requiring the geographical position with relation to markets and present railroad developments and prospective lines, character of coal and relative cheapness of mining, etc., to be taken into consideration, it would appear that, except for local uses and purposes, the northeastern Warrior field coals, including the coals at and north of Warrior Station and to the eastward, would not be available on account of high cost of production. The price for digging is 70 cents per ton, the seams being thin (3 feet) though of excellent quality.

The coking coals will naturally continue to be drawn from the established coking districts of the Warrior field and to some extent from the Cahaba field, being closer to the larger ore deposits and to the center of the iron-making district at Birmingham. Growth in iron production will naturally increase the consumption of these coals. As before remarked, most of the coals of the southeastern edge of the Warrior field are coking coals, though the present supply is mainly drawn from the Pratt and Newcastle seams, the former being from three and a half to four and a half feet thick, and the latter from seven to eight feet. The coals of the Pratt seam, paying forty-five cents for mining, cost about seventy-five to eighty-five cents on cars; while the coals of the Newcastle seam, paying forty cents for mining, cost from sixty to seventy cents on cars. These same coals, being excellent steam coals as well as coking coals, enjoy a wide market locally and for shipment outside of the immediate Birmingham district; but they are too soft and friable in structure to be used for domestic purposes and for purposes requiring handling as in the export trade.

The interior Warrior field coals, being harder, are largely used for domestic purposes and also for steam-making. For the former purpose they are shipped east to Atlanta and other points in Georgia; northwest to Memphis, and west and southwest to and even beyond the Mississippi River. At these points they meet competitive coals from other States, and their comparative use is limited by the railroad rates which they are required to pay. There being no through north and south lines of railway through

the Warrior field except the L. & N. Railway, which, as before remarked, taps only the thinner coals of the lower measures to the immediate north and east of Birmingham, the interior Warrior field coals, those of a harder character, are not available for southern shipment to any great extent. Their natural outlets are east and west, along the line of the Georgia Pacific Railway, and northwest on the Kansas City, Memphis and Birmingham Railway, with possible divergences for some distance north and south on crossing lines of railway outside of the main coal roads.

The Cahaba field, producing both steam and domestic coal, enjoys a favorable geographical location for such trade as may be developed to the South, Southwest and Southeast, being tapped by through lines diverging in these directions. This territory offers the most advantages, the main points being to a less degree subject to competition from other than Alabama coals.

Birmingham and its immediate vicinity is the dumping ground for almost all Alabama coals; for, being the headquarters for all the producing companies, business there is more actively worked.

The coal railways of Alabama have all established the rule of not allowing their coal cars to be shipped to points off their own or closely-allied lines. This makes it impossible for mines to compete successfully for business at local points on other coal roads.

The Louisville and Nashville Railway, with its operated line, the *Birmingham Mineral*, reaches north and south through both the Warrior and Cahaba fields, and by the Mineral branch taps many mines in the Cahaba field and along the southeast edge of the Warrior field. This road names " blanket rates " for all mines to Birmingham and to all local and competing points, thereby putting all its mines on an equality as to freight rates.

The *Alabama Great Southern*, extending through Jones Valley northeast to southwest, taps the coal fields at only one point, namely, through the Cahaba Coal Mining Company's road at Woodstock. This road then draws its supply from the Cahaba mines at Blocton and from those mines near Birmingham which, by their own short lines of road, reach all railroads. A Birmingham rate applies to all coal shipments on this road.

The *Georgia Pacific Railway* divides its mines into three dis-

tricts: an *eastern district*, including all the mines near, and twenty miles west of, Birmingham; an *intermediate district*, and a *western district*. The rates for each district vary for east and west shipments ten or fifteen cents per ton. Naturally, the western district coals go west, and the eastern district coals go east, while the intermediate mines ship domestic coals both east and west (the eastern coals being soft and friable), and steam coal mainly west.

The *Kansas City, Memphis and Birmingham Railway*, which ends at Birmingham, practically names a different rate for each mine. This places the intermediate mines at a disadvantage, the coals on this road being more alike than on the Georgia Pacific, where the intermediate mines furnish a coal quite distinct from the eastern coals, thereby allowing them to develop a trade of their own eastward. But Birmingham, being the eastern terminus of the road, places the eastern mines at a disadvantage, since they are unable to regularly procure a full supply of cars for shipments beyond Birmingham, on account of the rule before mentioned, and at the same time, by paying the local rate into Birmingham, are placed at a disadvantage as compared with other mines, which at once take the Birmingham rate to other points on such roads.

The *Columbus and Western* (*Central of Georgia*), though cutting the spoon-handle of the upper Cahaba field, is not distinctly a coal road, having but one operation on its line, which, on account of a bad roof and much water, produces an expensive coal. This road then draws its coal from the local mines near Birmingham, possessing their own lines of railway, and from the Georgia Pacific and the Kansas City, Memphis and Birmingham Railroad, the mines possessing the best local rates to Birmingham on their respective grades of coal being best able to compete for the business on the road. Steam coals come from local Birmingham mines, and from the eastern mines of the Georgia Pacific and the Kansas City, Memphis and Birmingham, and domestic coals from both the latter roads.

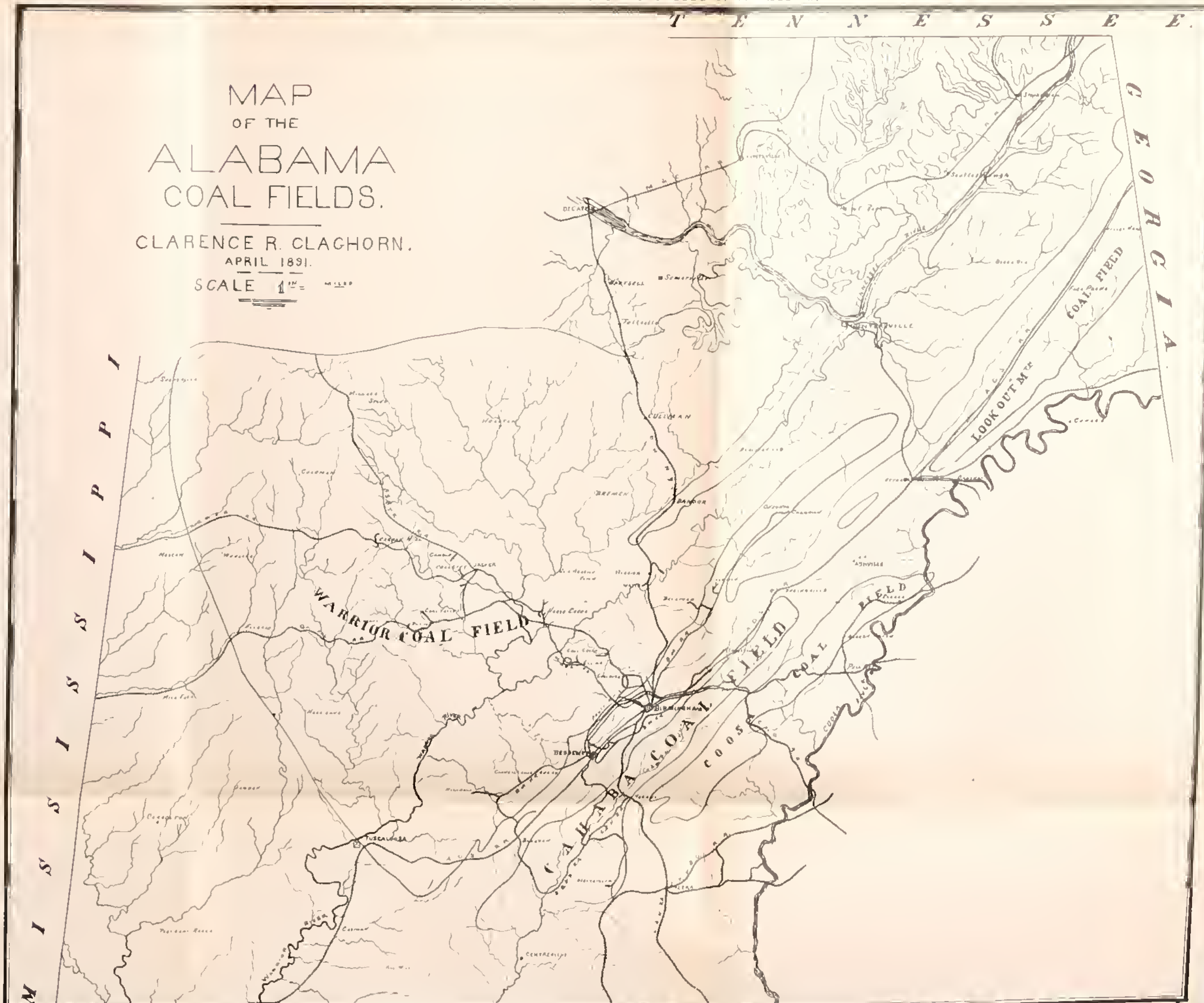
The Cahaba Coal Company, operating the only extensive mines in the Cahaba field, having much water and a poor roof to contend with, have established a relatively high price for their coal. This price has been also adhered to by the local mines, which have the advantage of freights to the southern territory. This

enables some interior Warrior field coals to reach these markets by absorbing the difference in rates in the f. o. b. mine price for coal, either by way of Birmingham or westward on the Georgia Pacific to a connection with the M. & O., Illinois Central, or L. N. O. & T., reaching south.

The interior Warrior field coals, lying in Walker and Tuscaloosa Counties, are undoubtedly the cheapest coals to mine, on account of their thickness, dip, character of roof, etc. It would appear that the needs of the district are either through lines of railway, extending north and south to tidewater, or branches of existing north and south lines, penetrating into the interior Warrior field by which an equitable rate and many other vital facilities for doing business in the southern territory could be given this field. By cheapening the cost, the use of Alabama coal will be extended.

The wonderful growth of industrial enterprises in Alabama, Georgia, Mississippi and Louisiana, the legitimate field for Alabama coal operations, will absorb a constantly increasing tonnage. This growth will call for more coal to the south and southwest than in other directions, outside of Birmingham's immediate vicinity; but this growth will hardly keep pace with the increased tonnage of the mines; for already an unhealthy state of the coal trade exists at certain seasons of the year, so that it is to an export business to the West Indies, Central and South America, Mexico and to American Gulf points, that Alabama must look for a market for her surplus coal. The coals most suited for this can only come from the Cahaba field, the mines near Blocton already doing considerable business of this kind, and from the interior Warrior field, which, as has been pointed out, lacks the railroad developments necessary to enable it to compete for the business.

Taking into due consideration the cheapness and quality of the coals, it would appear that the best of Alabama's territory has yet been untouched. A road passing northeast from Tuscaloosa would pass through a rich coal area, where the coals and coal measures are thickest, the coals of excellent quality, suitable for any purpose, lying favorable for mining in easy dips and under good cover. There are also portions of the Cahaba field, yet undeveloped, which give promise of a bright future.


MAP
OF THE
ALABAMA
COAL FIELDS.
CLARENCE R. CLAGHORN.
APRIL 1891.
SCALE 1 in =
T E N N E S S E E.
G E O R G I A.
M I S S I S S I P P I
WARRIOR COAL FIELD
CAHABA COAL FIELD
COOSA COAL FIELD
LOOKOUT MT COAL FIELD
CULLMAN
TUSCALOOSA

The accompanying sketch map indicates the outlines of the three coal fields mentioned herein, the data for its preparation being taken from personal notes and from the records of the State Geological Survey. It will be noted that the coal areas cover a large portion of North Alabama. The actual productive areas (that is, productive in the sense of being available in the near future according to present trade conditions) are, however, much smaller. The main coal seams, which are capable of being profitably developed under present market conditions, are confined to the middle and upper measures, which exist only in the southern and southwestern parts of the fields.

XX.

LAND-LOCKED NAVIGATION FROM LONG ISLAND SOUND TO THE MISSISSIPPI RIVER.

By Capt. Spencer C. McCorkle, Active Member of the Club.

Read April 21, 1891.

This project has received more or less attention, for more than twenty years, from many authorities, among which may be mentioned the President of the United States, the Corps of Engineers of the U. S. Army, officers of the Navy, civil engineers, and many business associations.

The writer of this paper refers to these authorities as giving a good reason why anyone possessing a knowledge of the subject, be it much or little, should do what may be possible to help along this good work.

President Grant, in his Fourth Annual Message, says: "Looking to the great future of the country, and the increasing demands of commerce, it might be well, while on this subject, not only to have examined and reported upon the various practicable routes for connecting the Mississippi with tide-water on the Atlantic, but the possibility of an almost continuous land-locked navigation from Maine to the Gulf of Mexico. Such a route along our coast would be of great value at all times, and of inestimable value

in case of foreign war. Nature has provided the greater part of this route, and the obstacles to be overcome are easily within the skill of the engineers."

It is not the present purpose of the writer to take up the routes from Long Island Sound to the mouth of the Suwanee. The very interesting paper submitted to the Society of American Civil Engineers by Mr. R. E. Peary, Civil Engineer U. S. Navy, which is published in pamphlet form, gives a resumé of this subject, *i. e.*, Ship Canals *et al.*, and is full of instruction. It is well also to quote from the report of Lieut.-Col. (now General) Gilmore, of the Corps of Engineers U. S. A., on "Water-line for Transportation from the Mouth of the St. Mary's River, on the Atlantic Coast, through Okefenoke Swamp and the State of Florida, to the Gulf of Mexico." Under the head of "Barge Water Line with Inside Barge Connection West," he says: "In determining the western terminus for a peninsula barge-canal from St. Mary's River, through the Okefenoke Swamp to the Gulf of Mexico, the advantages offered by the harbor of St. Mark's become at once apparent, whether considered with respect to either the inside or the outside connection west." From St. Mark's westward to Lake Borgne or Lake Ponchartrain, there exists a nearly continuous natural land-locked water-route, by means of tidal sounds, bays and connecting streams, requiring improvement by dredging in some places, it is true, but only a comparatively short aggregate length of solid cutting."

Under the head of "The General Character and Location of the Line," Col. Gilmore continues: "The probable nature and character of the project may therefore be summed up as follows: It will be a water-line for barges of 9 feet draught or less, commencing at the mouth of St. Mary's River, thence . . . . to the Suwanee River; thence descending that river by slack water and open river navigation to a point near Charles Ferry, and thence in a direction nearly due west, by canal, to the western terminus in deep water on St. Mark's River, a little below the town of St. Mark's." Estimated "total distance from mouth of St. Mary's to St. Mark's, 226 miles," "from Charles Ferry to St. Mark's by canal 70 miles."

The continuation of this report gives interesting information;

but sufficient has been quoted to indicate the utility of the project advocated in the remainder of this paper. An examination of the Coast Survey Charts will give nearly all the information that is required for both sections of the proposed improvement. Mr. R. E. Peary, Civil Engineer U. S. N., refers in his pamphlet (before mentioned) to another route of the Florida Canal, commencing at the St. John's River.

A Scheme of Land-locked Navigation from the Suwanee River, Fla., to the Mississippi.

(1) *From the Suwanee River to St. Mark's, Fla.*

An examination of charts Nos. 180 and 181 of the U. S. Coast Survey will show that the character of the coast presents no great difficulties to the canaling of about ninety miles of sea marsh.

Between the above points, five rivers and nine creeks empty into the Gulf, and the waters of these streams could be used for canal purposes. A line could also be found *inside* of the six-feet curve, and nearly as safe, owing to the character of the Shoals which would require only a portion of the route to be dredged to give an even depth of six feet the entire distance. Again, there is a partially protected route, with an average depth of eight feet, outside of the six-feet curve, with soft bottom all the way to St. Mark's.

Of course it is not practicable, without further examination, to make an estimate of the cost of either of these routes, or practically of the engineering difficulties. The object of the writer is simply to call the attention of the public to the feasibility of such communication, the practicability of which is shown on the Coast Survey Charts.

Mr. F. W. Perkins, Assistant, Coast and Geodetic Survey, says, in his report to the Superintendent: "The stretch of coast, including the working limits of this party, is low and marshy. On the land side, the line of woods in some places is only a quarter of a mile from the water line. In others, the forest is a mile distant, and, except at high tide, great mud flats impede the approach to the coast in boats. At several places, four miles off shore, the depth is only six feet at mean low water. . . . The

low, flat woods, devoid of prominent features distinguishable at a distance, and the consequent restriction in the placing of signals for angular measurement, a wide barrier of deep, soft mud, impeding at low water the movement of the sounding-boats as well as transfers for the plane-table party, and the necessity of working waist-deep on the overflowed marsh, have called for the employment of many expedients, but most of the hinderances were such as to be overcome simply by perseverance and endurance in the party. . . . . The results show the in-shore hydrography of the Gulf Coast, between Pepper Keys* and the mouth of the Ocilla River, and the channels of that and other rivers already named (referring to the Econfenee, Fenholloway and Steinhatchee) were developed. In general, the lines run in sounding the Gulf waters terminated at the depth of eighteen feet. The curve of that depth, as traced on the hydrographic sheets, is ten miles from the shore-line in some places, but on the average not much beyond seven miles. A heavy growth of grass springs up from the muddy bottom. The coral crops out frequently, and that formation is probably nowhere more than a few feet below the surface of the mud. . . . . *Anchorage is good in the offing, and, except near the points and capes, sufficiently smooth for the safety of vessels in almost any weather.*"

Assistant Perkins makes further remarks which will be found in the Coast Survey Reports of 1874, 1875 and 1876.

The writer of this paper calls attention to the latter part of the quotation from this interesting report, which he has taken the liberty to underscore.

With reference to the coral rock, it is somewhat remarkable that it is only between St. Mark's and Key West, Fla., that this *or any other* species of rock occurs on the Gulf Coast of the United States.

This part of the coast is unlike any other known to the writer. It is peculiar in its character, and the back country of Lafayette, Taylor and Jefferson Counties is well worthy of further investigation.

Some fifteen or twenty years ago an effort was made by the

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* The Pepper Keys are twenty miles south of the Suwanee.

writer and others to attract attention to the Peninsula of Florida, but the project was rejected at once as a delusion and a snare. "It was a region of impenetrable swamps" where no white man could live, etc., etc. The present status of Florida shows what can be done by zeal, intelligence, and last, but not least, money. Before many years, if not already so, the Peninsula will be one of the "garden spots of the world."

The proposed canal will open the way for a similar improvement in the adjoining counties to the west, where the soil and climate are about the same, with this exception, that the east wind has no terrors.

The writer has so far relied, for the most part, upon the charts and reports of the United States Coast Survey; but from the mouth of the Ocilla River to the western arm of St. Andrew's Bay, he has sailed over the entire coast, anchoring frequently in the bays, and off the principal points, and is therefore familiar with the surveys, of which, in most cases, he has borne a part.

(2) *From St. Mark's to Apalachicola, Fla.*

The distance from St. Mark's to Apalachicola, following the coast line, is about sixty-one miles. By the Ocklockony and Crooked River route the distance will be increased about ten miles, perhaps.

The depth on the bar, at the entrance to St. Mark's River, is $11\frac{1}{2}$ feet at mean low water; and not less than 7 feet, in one or two places, can be carried to the town of St. Mark's, which is near the confluence of the St. Mark's and Wakulla Rivers, and distant from the bar nine miles. The depth of water in this river can easily be increased. In passing up the river from the bar, and passing St. Mark's Lighthouse and the mouth of the East River, what was once Port Leon is seen. The only objects of interest next are the ruins of the Old Spanish Fort, St. Mark's, the Wakulla Spring and the town of St. Mark's.

The first and second are worthy of investigation. The latter, as it used to be in 1855, was of little importance; but now that it is the terminus of a branch of the Pensacola and Georgia Railroad, by which it is thirty miles from Tallahassee, it may be much improved. The depth of water, at the wharf at St. Mark's,

is ten feet. Tallahassee, the capital of the State of Florida, is one of the loveliest places in the South. It is worthy of note that St. Mark's is the only port between Cedar Keys and Pensacola that has a railroad connection. Several other routes have been projected, but no other roads have been built, as far as the writer has been able to learn.

It would not be difficult or very expensive to dig a canal from the deep water of the St. Mark's River to Ocklockony Bay through the sea marsh inside of Shell Point, which is about half-way; but with a little improvement a line can be had outside of the shoreline, but protected from heavy seas by Ocklockony and other shoals. Experience has shown that anchorage inside of these shoals is safe and secure in nearly all kinds of weather, and navigation also. An examination of Chart No. 182 will give much corroboratory information.

Ocklockony Bay is a very pretty sheet of water, about $6\frac{1}{2}$ miles long and $1\frac{1}{2}$ miles wide, with generally sandy shores. A depth of eight feet can be had in the bay and up the river to its junction with Crooked River. Mr. Jos. Hergesheimer made a survey of the latter river in 1878, a map of which can be seen at the Coast Survey Office, Washington. The least depth noted in Chart 182 of this river is three feet, with intervening depths of ten feet. The island between Crooked River and St. George's Sound is called St. James' Island. It is about 22 miles long and 6 miles wide in the extreme, but averaging about $3\frac{1}{2}$ miles. The Gulf front of this island is from 10 to 15 feet above sea-level, with a gently rolling country at the back of it. It has quite a heavy growth of pine woods, and several large lakes or ponds of water close to the small settlement; and there is a road from it to Tallahassee. As a site for a winter or summer resort the writer knows of none more salubrious, unless it may be at St. Andrew's Bay.

A natural harbor, Alligator, is at its front, with at present a depth of only six feet, but both the entrance and harbor can be deepened.

It is also practicable to make a cut into this harbor from Ocklockony Bay, of about five miles of land and water, which would reach St. George's Sound by a shorter route than by Crooked River, but it would not be land-locked. A stretch of open water

between Southwest Cape and Dog Island, although partially protected by outer shoals, is sometimes subject to heavy seas. It was thought at one time that a deep-water channel (called the Duer Channel) had been discovered hereabout, and there is reason to believe that 21 feet in depth can be had with a little improvement.

At the mouth of Crooked River, where it empties into the sound, a depth of 4 feet is given on Chart 182, but there is reason to think that the depth has been increased, as a settlement of some importance (Carrabelle) has been located at the mouth. Either a jetty system or a breakwater may be necessary at this point, as it is nearly opposite the East Pass of St. George's Sound. This "Pass" is between Dog Island and St. George's Island, and is the present deep-water channel into the sound. There is a depth of water of 18 feet on the bar; and the channel, which is close to Dog Island, finally reaches an excellent anchorage, of not less than 21½ feet, in soft, muddy bottom.

Thence the route is westerly, through the sound, carrying at least 10 feet to Bulkhead Shoal, which is narrow and can be easily improved. The highest bluffs on the shore of the Gulf coast of Florida, Royal and Topsail Bluffs, are found in this vicinity. St. George's Island on the South is similar to the general run of islands on the coast, and was once covered with a heavy growth of timber, consisting of pine and red cedar. Not much of the latter growth remains, but the pines are still numerous in places. From Bulkhead Shoal to the bar at the mouth of the Apalachicola River is plain sailing with from 10 to 12 feet at mean low water. Apalachicola Bay, near the western end of the sound, is about 12 miles long and about 6 miles wide. The distance from Cat Point to Apalachicola is about 6 miles; and, north of a line drawn between the two points, is the Delta of the Apalachicola River. This river and the Chattahooche are navigable for steamboats at least 450 miles, not including the branches to Bainbridge, Ga., and Marianna, Fla. At Chattahooche, just below the junction of the main river and the Flint, there is a railroad bridge.

Apalachicola, at the mouth of the river, was, in the *ante-bellum* days, a large cotton port, as many as 250,000 bales having been exported in one season.

The cotton was brought down the river in steamboats and barges, and, after being compressed, was lightered to the shipping at the East Pass and West Pass anchorages. Return freight was also received from foreign, northern and southern ports, loaded in the sound, and carried up the river.

The depth of water on the bar below the town, as reported by the Corps of Engineers U. S. A., is 6 feet, but it is expected that it will be 12 when the present work on it is finished.

Though the *cotton* no longer comes to this port in large quantities, as of yore, saw-mills have been erected, and quite a large *lumber* trade has started up. The town itself is healthful, is well located, and has plenty of room to expand. Some of the finest timber found in any southern locality is floated down the river to this port.

The attention given to this locality is owing to the fact that Apalachicola is the only seaport of any importance between Tampa Bay and Pensacola, and it is well to remark in reference to it that the cotton trade was destroyed by the changes in the mode of transportation during the war, when trade was diverted from the rivers to the rail. Now the rivers are beginning to take up their natural work again; for while it takes a great deal of capital to build and run a railroad, a comparatively small capital is required to build a steamboat or sailing-vessel, and navigation is free to all.

Only lately the canal passing the Muscle Shoals of the Tennessee River has been opened, giving steamboat navigation from the Mississippi River and its branches to Chattanooga and Knoxville, Tenn.

(3) *From Apalachicola to St. Andrew's Bay.*

Two routes are presented, the first following the coast-line, which at some points is not fully protected, the second entirely land-locked.

(*a*) *The line via St. Vincent's Sound and St. Joseph's Bay.*—By dredging out a few oyster bars, a depth of at least 7 feet can be carried to Indian Pass, 14½ miles west of Apalachicola. From Indian Pass to St. Joseph's Bay and through Indian Lagoon a cut will have to be made, 3 miles of which will be through

sand and marsh, to 9 feet of water in St. Joseph's Bay, a distance of about 7½ miles; thence to St. Andrew's Bay, about 21 miles.

About half-way between Indian Pass and St. Joseph's, quicksand is found along the coast, and this might make this route expensive. Many years ago, a road near the north shore, and reaching from Apalachicola to Ferry Point, St. Andrew's Bay, was built by the U. S. Army. Traces of this road can yet be found.

A strip of sand beach, less than a mile wide, separates St. Joseph's Bay from the Gulf, north of Cape San Blas. The lighthouse at the latter point was destroyed some years since, but has since been rebuilt on another site. The cause of the accident is to be found in the peculiar ideas that exist in the minds of some people as to the removal of the barriers formed by nature for the protection of the coast, and providing nothing defensive in lieu of the natural formations. Then comes the assertion that the coast is gradually *receding*. It is somewhat remarkable that nothing is ever said by such persons of that part of the coast which is *making*.

After rounding Cape San Blas, the sand beach continues in a northerly course to St. Joseph's Point, one long ridge of sand, which incloses the southern arm of St. Joseph's Bay. The widths of this long strip of beach vary. About midway, and opposite Eagle Harbor, the distance from the bay to the Gulf is only about 300 feet.

The entrance to St. Joseph's Bay is nearly 1½ miles wide, with one lump on which is 18 feet, but 20 feet is the least depth over the bar leading to an anchorage, safe and secure, of from 5 to 6 fathoms. Indeed, the whole western part of the bay has deep water, and 9 feet can be carried to within a mile of the head of the bay. Eagle Harbor is quite noted as a point of refuge for small vessels, and large ones also.

The head of the bay is generally shoal, and it is also shoal along the northern shore. Opposite the site of the old town of St. Joseph it is about 1,800 feet to 14 feet of water. This town was once an important shipping point. It had large receipts of cotton, which were received via the Apalachicola River, and a railroad from Iola; and in 1835 it had a branch of the United States

Bank, quite a number of comfortable houses and a numerous population. Now only flowers and fruit-trees tell the tale of former prosperity.

The bay is extensive, as a reference to the charts will show, and some day it will again be of consequence, owing to the large depth of water and the salubrity of the climate.

About northwest of St. Joseph's Point is a shoal, on the northern end of which the sea breaks in violent storms, but inside of it there is plenty of water, and along the shores of the island a channel of not less than 16 feet.

St. Andrew's Point is about 8 miles from St. Joseph's Point. Near the former is a narrow strip of land separating St. Andrew's Sound from the Gulf. By cutting through about $\frac{1}{8}$ of a mile, and dredging about 2 miles in places, a depth of 9 feet can be carried to the western arm of St. Andrew's Bay.

Having to pass the open sea in two places may, however, be an objection to this route. The preference is altogether in favor of the route via the Apalachicola and Wetappo Rivers, which will be next referred to. Reference is made in the former case to Charts 183 and 184.

(*b*) *The line via River and Canal to St. Andrew's Bay.* Whether the connection on this route can be made direct from Apalachicola, or through what is called the "Dead Lakes," or from the Chipola, a branch of the Apalachicola, the writer is unable to tell at present, but he was told by good authority that, during the war, boats were hauled across from the Wetappo River, emptying into St. Andrew's Bay, to the Apalachicola. It was not possible at that time to make any verification of this statement, therefore in carrying out this scheme a special survey will have to be made. The distance from river to bay was estimated at about 6 miles, and I refer to the Wetappo, assuming that (as is generally the case in the streams hereabout) a good depth can be found in that stream in the direction of the Apalachicola.

After crossing the bar of the Wetappo into St. Andrew's Bay, there will have to be dredged a channel, which has now from 2 to 7 feet, a distance of about $2\frac{1}{2}$ miles, with plenty of water through the bay to within 2 miles of West Bay Creek at the western end of the bay.

St. Andrew's Bay is one of the finest on the Gulf Coast, and would be noted everywhere, except that the depth of water on the bar, at the entrance from the Gulf, is only 14 feet. The writer thinks that if engineering skill were exercised a greater depth could be obtained. Once inside of the bay, the depth increases to from 4 to 7 fathoms.

Lieut. (now Commander) R. D. Hitchcock, U. S. N., in his report to the Superintendent of the Coast and Geodetic Survey, writes: "St. Andrew's Bay is a most beautiful sheet of water, and everything about it is pleasant to the eye. It abounds in fish of all kinds, and oysters. Large quantities of pompano, Spanish mackerel, blue fish, red fish, grouper, sea trout and mullet are taken. Oysters found in the eastern part of the bay are eaten at all times of the year, but those of the North and West parts only during the winter months. During summer the shores of the bay are resorted to by families from northern Florida and southern Georgia, who thus avoid the intense heat of the interior, and the so-called *swamp* fever, a fatal disease that prevails in hot weather at places only sixty miles from the Gulf Coast. St. Andrew's Bay is said to be one of the healthiest places along the Gulf of Mexico. The climate in winter is delightful; and in summer, though the air is always warm, the wind blows almost constantly from some southerly direction during the day, and by this wind the temperature is kept down."

The writer fully indorses all that Lieut. Hitchcock has said, and possibly could add something from his own experience, but refrains, being unwilling to be suspected of personal enthusiasm, even though backed by such responsible testimony.

It only needs, after what has been said above, to draw attention to Chart No. 184, which develops this remarkable sheet of water.

If the depth of water over the bar could be increased (and that is possible), no better site for a great port could be found in Gulf waters. The writer is aware that an "if" is generally considered a *doubtful* question.

(4) *From the Western Arm of St. Andrew's Bay to Mobile Bay.*

The charts of the Coast and Geodetic Survey give nearly all the information that is required for this part of the route. See Charts 185 and 186.

The experience of the writer goes no further than the former of these two points. If, however, wading in water waist-deep is any indication of canal facilities, a great deal of such testimony can be furnished.

It appears, from such maps as are available, that in all probability the waters of West Bay Creek, emptying into St. Andrew's Bay, and the water of Choctawhatchee River, emptying into the Bay of that name, find their source at nearly the same point. A survey may be necessary to settle this question, though it is possible that the district surveys may give the required information. The distance from bay to bay is about fourteen miles.

Choctawhatchee Bay contains very deep water, and is about twenty-five miles long; average width, four miles. About six miles from the eastern end, which has nine feet, the bay deepens to twelve feet, and no less depth is found to the entrance of Santa Rosa Sound.

The characteristics of this bay are about the same as the bays and sounds along the Gulf Coast.

Assistant Herbert G. Ogden, who made the survey of this locality, reports as follows:

"The Gulf Coast between Choctawhatchee Bay and Pensacola Bay, a distance east and west of about forty-five miles, has been thoroughly surveyed. . . . . Santa Rosa Sound connects the waters of the two bays, and is separated from the Gulf by a low, sandy island fifty miles long. The width of this barrier at the average is about a quarter of a mile. Santa Rosa Sound itself, stretching east and west, varies in breadth, being two miles across toward the western end, where it joins Pensacola Bay, but less than 300 yards near its entrance into Choctawhatchee Bay. Santa Rosa Island, as represented on the plane-table sheets, is covered in spots with grass and pine trees. Patches of marsh are met in a few places along the inside shore. The sand-hills on the island are generally isolated, but in a few instances they occur as ridges. Along the Gulf shore, however, a nearly continuous ridge of sand from five to ten feet high, and covered with grass, presents a barrier so effectual that the island has nowhere been cut through by the waters of the Gulf. In many places the ridge shows like an artificial structure, so regular are the slopes.

The topographical survey shows but one break in the entire length of this peculiar sand-barrier. The mainland, or north shore of Santa Rosa Sound, is mostly swampy to a distance of a quarter of a mile from the water-line, and is covered with a growth of pines, among which are a few live oaks."

Off Deer Point, at the western end of the sound, Mr. Ogden found a depth of twenty-five feet. "Ten miles eastward, the depth in Santa Rosa Sound is no more than eighteen feet. Twenty miles east of Deer Point there is only twelve feet, and then occurs the first bar across the sound, the least depth being eight feet. Going farther eastward and through the narrows, the channel is tortuous, with frequent bars, four of which are used as crossing places, the depth being only four or five feet, but there are intervening depths of more than twenty feet."

"On the bar of East Pass the sounding party found a depth of about eight feet, and somewhat more through the Pass into Choctawhatchee Bay. The current was very strong through the Pass."

From Pensacola to Mobile Bay, the distance is about twenty-seven miles, and, according to the charts, a connection between the two points can be made by a canal of six miles, and by dredging at various points, of which a later survey, not yet published, will give interesting information.

It is proposed that Bon Secours River be used as an entrance into Mobile Bay. Some dredging will be required at the mouth of this river where it will not be difficult to construct a basin, where light-draught vessels would find a harbor in case of heavy weather in the bay.

Chart No. 188, and the new charts yet to be published, will give very much of the information required.

(5) *From Mobile to New Orleans.*

The city of Mobile, which is at the head of the bay of that name, and at the mouth of the Alabama River and its tributaries, is the second largest city on or near the Gulf Coast. Steamboats navigating the Alabama, Warrior and Tombigbee Rivers sometimes proceed direct to New Orleans via Mobile Bay, through Grant's Pass (a private enterprise) to Mississippi Sound, and then through the "Rigolets" and Lake Ponchartrain to the

lake end of the Ponchartrain Railroad. Before the war, and before the completion of the Mobile and New Orleans Railroad, elegant steamboats used to ply on this route, carrying the mail and passengers and stopping at various ports in Mississippi Sound.

Through the channel, dredged by the United States, fourteen feet of water can be carried from Mobile to very near Grant's Pass. The present depth through this Pass is from seven to nine feet; but it can be improved, and will be, as soon as greater trade is developed. From Grant's Pass westerly through Mississippi Sound, a depth of ten feet, with some dredging at the "Rigolets," can be carried to the railroad and canal terminus on Lake Ponchartrain; but as two railroads cross a portion of the lake near its eastern end, it seems to the writer that it would be best to avoid this route and look to a connection with the Mississippi by the Lake Borgne Canal. There is not quite so much water at the end of this route—the least seven feet, with soft, mud bottom—but the canal, which is only a few miles below New Orleans, gives an almost completed entrance to the Mississippi River, which would give, for about 550 miles, a canal and sound navigation which would not cross any railroad.

The route via Mississippi Sound, etc., passes, on the south, Dauphin Island, Petit Bois Island, Horn Island, Ship Island and Cat Island. The latter island has a great movable sand-hill, very similar to those that are found elsewhere on the coast, only at Cape Henlopen, Del., Cape Hatteras, N. C., and perhaps at Cape San Blas, Fla.

The islands, with the exception of the east end of Dauphin Island, Ship Island, and the Keeper of Cat Island Light, are uninhabited, at least during the winter.

The north shore from Mobile Bay to the "Rigolets" is one of the most delightful parts of the Gulf Coast, and has the advantage of being inhabited almost the whole distance.

Pascagoula, Miss., at the mouth of the river of that name, is a place of importance and is a port of entry. From it large quantities of lumber have been shipped since 1846 to various ports. As a place of residence it has many advantages; formerly it had only a steamboat connection, or a long ride through the

sand to Mobile. Now, the Louisville and Nashville Railroad gives it connection with all parts of the country.

Nearly south of the latter point, and in about the middle of the sound, is a peculiar-shaped island, called Round Island, upon which there is a lighthouse. The main channel passes south of this island.

The next noticeable point is Biloxi—a settlement of much interest—and then follow Mississippi City, Pass Christian and the Bay of St. Louis. The railroad touches all these points, and each one of them has its attractions. Hotels have been built, and shell-roads have been laid out on nearly the whole length of this part of the coast, making it a most delightful site for winter and summer residences.

The prevailing *cold* wind in winter is the "Norther," which, in exposed places, is not agreeable; but the inner coast line is protected from this wind by magnificent forests, containing many varieties, such as Live Oaks, Magnolias, Pines, etc.

In conclusion, the writer will say that he has endeavored simply to show the probabilities of land-locked navigation, covering a locality which is very familiar to him, but of which little is known in this latitude. A professional interest, and also a request from some valued friends and co-laborers, have led him to take up this subject while it is called to-day.

It is a matter of pride that the Coast Survey Charts furnish nearly all the information that is needed for estimating the cost of such an improvement. At three places only is any further examination needed, namely, the interior, perhaps, from the Suwanee to St. Mark's, Apalachicola River and the crossing to St. Andrew's, and the topography between St. Andrew's and Choctawhatchee Bays.

In the very shoal places requiring improvement, a tracing from the original sheets, which are on a larger scale, will give the desired information. At least such is the opinion of the writer.

It is also believed that it is possible to dredge out a canal, of the required depth, outside of the shore-line between St. Mark's and the Suwance, making an embankment of the dredged material, and, as it were, a new shore-line, to be protected by the outside shoals, the possibilities of which are shown in this paper.

Further information can be obtained from an inspection of the charts.

It is believed that if the trade demands it, a depth of twelve feet can be had through the whole route. The project, which includes inland navigation on the Atlantic as well as the Gulf Coast, hinges upon one improvement, and that is the Florida Ship Canal.

It would be well to take up the possibilities also of the Atlantic Coast in this connection, and it may be that some ready writer will give it attention. If the scheme for the Ship Canal is carried out, of which there is every reason for hope, then it will naturally follow that internal navigation, from Long Island Sound, not only to the Mississippi, but to the Rio Grande, will be looked to, not only for its commercial advantages but also as a measure of defense.

If engineers, military and civil, and the commercial bodies in the North and South, would memorialize Congress to the effect that an experienced engineer should be sent to make a reconnoissance of the whole route, and to report, it would be a step in advance for an improvement that, in the opinion of the writer, is sure to come.

No sketches accompany this paper. Those interested are referred to the Charts of the U. S. Coast and Geodetic Survey from No. 180 to 191 (inclusive). A sketch would give the outlines only, and these can be obtained from any map of Florida; but the charts, which are very accessible, give nearly all the details.

Extracts from letters written by Col. P. H. Raiford, of Georgia, and Col. C. G. Forshey, Chief Engineer Louisiana Levees, accompany this paper (see Appendices A and B).

Appendix A.

Extract from a letter written by Col. P. H. Raiford to the *Savannah Morning News*, and referred to the Chamber of Commerce of Savannah, Ga.: . . . . "Familiar, as most well-informed persons of the South are, with the general characteristics of the Mexican Gulf Coast, with its bays, lakes and sounds, but few have had their attention called to the practicability of utilizing, by cheap improvements, the inner waters of this shore, so as

to make them form, for the purposes of navigation, a connecting link for all the rivers which flow through them into the waters of the Gulf.

"From the Mississippi to the Apalachicola River the distance is about 400 miles. Between these rivers, those of the States of Mississippi and Alabama debouch into a system of land-locked estuaries which stretch eastward and westward along the shore to points very nearly of contact, the severing of which by canals will constitute the work which will bring together the navigation of these different rivers, without at any point touching the waters of the Gulf or waters at all hazardous for inland boats." . . . . .

"The Lake Borgne Canal, which leaves the Mississippi just below New Orleans—now nearly completed (1873) . . . . . . will perfect a line of land-locked navigation from the Mississippi to the eastern arm of Mobile Bay, 168 miles. From Mobile Bay, a cut of five miles will continue the same character of navigation to Perdido Bay; four miles more will bring it to Pensacola, Santa Rosa Sound and Choctawhatchee Bay, all in a continuous line eastward, and to within nine miles of St. Andrew's, which reaches a point from which a cut of six miles will connect the whole system with the Apalachicola. Thus it will be seen that about thirty miles of canaling—mostly through sea marsh—is necessary to be done, to enable the boats of 20,000 miles of navigable water-lines to reach a point within 250 miles of the city of Savannah, and to reach the present terminus of the Atlantic and Gulf Railroad."

Note.—Nearly the whole of this route is shown on the Charts of the Coast and Geodetic Survey. If Col. Raiford had referred to these charts, much more attention would have been given to his project.—S. C. McC.

Appendix B.

Extract from a letter from Col. C. G. Forshey, Chief Engineer Louisiana Levees, to the Savannah Board of Trade (1873):

. . . . . . "The Gulf Coast can be traversed by a canal that may receive and bear away, without break of bulk, the products of the Mississippi Valley to the remotest navigable rivers of the four Gulf-front States, and across the Peninsula to the Atlantic; and while I am sure this line may be extended to the Delaware

and Chesapeake Bays, and to the east end of Long Island Sound, my present information is of that general character which, as a professional engineer, I would not act upon without further investigation of the data which are readily attainable."

Appendix C.

Lake Borgne Canal (from the paper of Mr. R. E. Peary, Civil Engineer U. S. Navy), 1889.

"From Lake Borgne to the Mississippi River. Length, twelve miles; length of locks, 350 feet; estimated cost, $450,000. Will save coast trade, east of New Orleans, a voyage of 265 miles."

Appendix D.

From the Philadelphia *Public Ledger* of March 28, 1891.

"The U. S. Revenue steamer, Lot M. Morrell, has arrived at Charleston, South Carolina, having made an inland passage all the way up from North Edisto River. The feat of the Morrell is deemed of great importance, from a military point of view, as it has demonstrated the ability of small war vessels, drawing no more than ten feet of water, to navigate inland all the waters of the southern coast from Charleston to Fernandina and from Philadelphia to Fernandina, save for a small stretch of coast lying between Moorhead City and Charleston. It is expected that a system of torpedo flotilla service will shortly be devised to take advantage of this inland navigation for purposes of coast defenses. The Morrell was built at Wilmington, Del., by Pusey & Jones Co. in 1889, is 145 feet long, draws nine feet of water, carries a Hotchkiss battery and a crew of thirty-eight, and is commanded by Lieut. W. S. Baldwin."

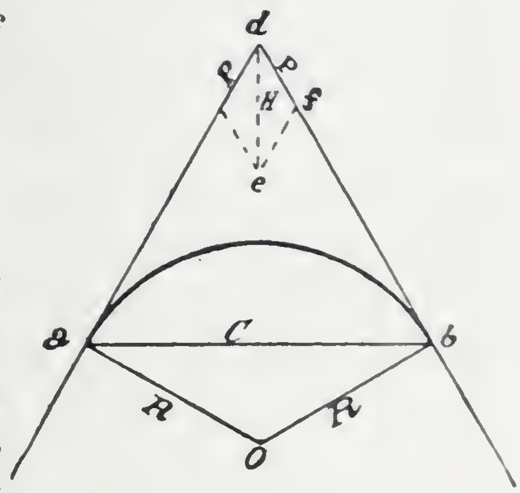
THE THEORY OF CURVED DAMS.

A. MARICHAL, January 21st, 1888.

Supposing a dam, without any thickness, without any weight, built on a curve of a radius $= R$, and resisting to the water pressure, the reactions of the abutments will have to make equilibrium to the total pressure of the water.

Calling C the length of the chord, and P the reaction of the abutments, we have the formula

$$P = \frac{H\,R}{C}$$



deduced from the similarity of the triangles $a\ b\ o$ and $f\ e\ d$. H is equal to the horizontal thrust of water (h) on a belt one foot long, multiplied by the length of the chord.

Hence

$$P = \frac{h\ C\ R}{C} = h\ R \quad (1)$$

In practice we are compelled to give some thickness, consequently some weight to the structure; this weight will produce a resistance to the horizontal thrust of the water, and the excess will have to be equilibrated by the reaction of the abutments.

The first case to be considered is the possible sliding motion of the voussoirs. The force which could possibly be transmitted to the abutments is

$$h - k\ w$$

w = weight of masonry above joint; k = coefficient of friction of material. Substituting this value in equation (1) we have

$$P = (h - k\,w)\,R.$$

To have the average pressure on the abutment we must divide by the height (D) of the wall above the joint:

$$P_1 = \frac{(h - k\,w)\,R}{D}$$

The centre of pressure being practically at $\frac{D}{3}$ above the joint (neglecting the height of the crown), the maximum pressure will be double the average one, or

$$P_2 = 2\,\frac{(h - k\,w)\,R}{D}$$

Dividing by the depth (B) of the voussoir joint we have the maximum pressure per square foot.

$$p = \frac{2\,(h - k\,w)\,R}{D\,B} \qquad (2)$$

The second case to be considered is the possible yielding of the wall. The elasticity of the material cannot be ascertained with any degree of accuracy; we must neglect it and make allowance for this omission. The force to be equilibrated by the reaction of the abutments is

$$h - \frac{M}{L}$$

in which M = moment of resistance produced by the weight of the wall; L = distance of centre of pressure of the water above joint.

To make allowance for the omission relating to the elasticity, it will be safe to suppose that double the amount is transmitted to the abutments, or

$$2\left(h - \frac{M}{L}\right)$$

Substituting this value in equation (1) we have

$$P = 2\left(h - \frac{M}{L}\right) R$$

The reaction will be maximum at the top and 0 at the bottom, consequently will have its centre of pressure at $\frac{D}{3}$ from the top; that is, acting with a larger lever and reduced as follows:

$$P_1 = \frac{2\left(h - \frac{M}{L}\right) R\, L}{\frac{2\,D}{3}}$$

Dividing by the height of the wall (D) and multiplying by 2 we will have the maximum pressure on the voussoir joint at the top, which divided by the depth (B) of the voussoir joint, will give the maximum pressure per square foot.

$$p = \frac{2 \times 2\left(h - \frac{M}{L}\right) R\, L}{\frac{2\,D}{3} \times D\, B}$$

$$\text{or } p = \frac{4\left(h - \frac{M}{L}\right) R}{\frac{2\,D^2\,B}{3\,L}}$$

In practice $3\,L$ may be supposed equal to D, and the formula becomes:

$$p = \frac{2\left(h - \frac{M}{L}\right) R}{D\,B} \qquad (3)$$

It will be found that the equation (2) will generally give a much higher value for p, and will consequently be the

only one to use in common practice. Moreover the omission of the cohesive power of the mortar makes the result perfectly safe.

For ordinary rubble masonry the coefficient of friction may be assumed at .7, and the formula (2) becomes:

$$p = \frac{2\,(h - .7\,w)\,R}{D\,B}$$

According to the formula, the intensity of the reaction does not change with the length of the chord. In practice it is also correct, but in long spans the point of application may change; thus causing an uneven distribution of pressure on the joint. It is advisable to assume lower limits in long spans than in short ones.

A safe limit for crushing strain, in ordinary circumstances, will be 9 tons per square foot for mortar rubble.

STEAM FORMULÆ.

COMPILED CHIEFLY FROM RÖNTGEN'S THERMODYNAMICS AND ARRANGED IN CONVENIENT FORM FOR PRACTICAL USE.

L. F. Rondinella, April 21st, 1888.

Notation.

p = pressure.
t = temperature (Centigrade).
C = mean specific heat of water.
q = heat of the liquid, or sensible heat.
W = total heat of saturated steam.
r = " " " vaporization, or latent heat.
ρ = inner latent heat.
A = heat equivalent of 1 meter-kilogram = $\frac{1}{424}$ ht. units.
σ = specific water volume = .001 cu. meter per kilogram.
s = " steam "
u = difference of specific volumes = $s - \sigma$.
T = absolute temperature = $273 + t$.
x = initial quantity of steam in 1 kilog. steam-and-water mixture.
Q = quantity of heat, in heat units per kilogram.
w = velocity.
G = weight.
v = specific volume of steam-and-water mixture.

Formulæ.

To find pressure of saturated steam of given temperature:

(1) $p = 4.525 \times 10^{\frac{7.4475\, t}{234.69 + t}}$ millimeters of barometer.

(1) multiplied by $\frac{14.7}{760}$ gives p in lbs. per sq. inch.

To find mean specific heat of water between given temperatures:

(2) $C = 1 + .00002(t_1 + t) + .0000003(t_1{}^2 + t_1 t + t^2)$ heat units.

To find amount of heat required to raise 1 kilogram of water from one given temperature to another:

(3) $q_1 = C(t - t_1)$ heat units.

To raise from 0° to $t°$, — the "sensible heat":

(4) $q = t + .00002\, t^2 + .0000003\, t^3$ heat units.

To find amount of heat required to raise 1 kilogram of water from 0° to saturated steam of given temperature, — the "total heat":

(5) $W = 606.5 + .305\, t$.

To find amount of heat required to change water of a given temperature into steam of the same temperature, — the "latent heat":

(6) $r = W - q =$ equa. (5) — equa. (4).

(6*a*) or (less exact) $r = 607 - .708\, t$.

To find amount of heat required for *change of state* in changing water of a given temperature into steam of the same temperature, — the "inner latent heat":

(7) $\rho = 575.4 - .791\, t$.

To find amount of heat required to overcome a given external pressure (corresponding to temperature t) in changing water into steam, — the "outer latent heat":

(8) $Apu = r - \rho = 31.6 + .083\, t$

To find the value of u for a given temperature t:

(9) $u = \dfrac{62.328\, r}{(p - p_1)\, T}$ in which p corresponds to $(t + 1)°$, and p_1 to $(t - 1)°$.

$$(10) \quad \text{or (less exact) } u = \frac{Apu}{Ap} = \frac{(31.6 + .083\,t)\,424}{p \text{ kil. per sq. m.}}$$

To find specific volume of saturated steam of given pressure, or *vice versa:*

(11) $1.704 = p\ s^{1.0646}$ (p in atmospheres).

To find amount of heat imparted to keep 1 kilogram of steam of given temperature saturated, when it expands doing work, to a temperature 1° lower:

$$(12) \quad h = \frac{r}{T} - .305.$$

$$(12a) \quad \text{or } h = \frac{800.3}{T} - 1.013.$$

Equations of relation for different properties of steam-and-water mixture when heat is imparted or abstracted, while volume remains constant:

$$(13) \quad x_1 = \frac{u}{u_1}\,x.$$

$$(14) \quad Q = q - q_1 + xu\left(\frac{\rho}{u} - \frac{\rho_1}{u_1}\right).$$

To find in what time the steam pressure in a boiler will rise to a certain figure, when from a given instant no more steam is drawn off:

Let Z = required number of minutes.
Q_m = heat units imparted per minute.
G = kilograms water and steam in boiler.
p = initial pressure; t = corresp. temperature.
p_1 = final " ; t_1 = " "

$$(15) \quad Z = \frac{G}{Q_m}(t_1 - t)\ C.$$

To find quantity of water to be supplied to surface condenser:

Let n = kilograms of water necessary to condense each kilogram of steam.

t = temperature of entering water.

t_1 = " " departing "

t_0 = mean temperature of condenser.

(16) $$n = \frac{600 - t_0}{t_1 - t}.$$

To find quantity of water to be supplied to jet condenser:

(17) $$n = \frac{600 - t_0}{t_0 - t} \text{ (notation as above).}$$

To find the ratio of feed water to steam used in an injector:

Let G = kilograms of water per second.

G_0 = " " steam " "

t = temperature of feed water.

t_0 = " " steam.

t_1 = " " mixture (entering boiler).

(18) $$\frac{G}{G_0} = \frac{606.5 + .305\, t_0 - t_1}{t_1 - t}.$$

To find velocity of efflux of steam per second when heat is neither added nor abstracted (adiabatic expansion):

(19) $$w = 91.2\sqrt{\frac{x\,(607 - .708\,t)}{273 + t}\,(t - t_1)} \text{ meters.}$$

To find steam weight discharged per second through orifice of area F sq. m.:

(20) $$G = Fw \left(\frac{p_1}{p}\right)^{888} \times \frac{1}{v} \text{ kilograms.}$$

DIMENSIONS OF PIPE FLANGES AND CAST-IRON PIPES.

J. E. CODMAN, MAY 4TH, 1889.

Dia. of Pipe.	Dia. of Flange.		Dia. of Bolt Circle.	Dia. of Bolt.	No. of Bolts	Thickness of Flange	Thickness of Pipe.		Weight per Foot without Flange.	Weight of Flange and Bolts
	Diagr.	Form.					In 32.	Dec.		
2	6 1/4	6 1/2	4 3/4	3/4	4	5/8	3/8	.373	6.96	4.41
3	7 1/2	. .	5 7/8	3/4	4	5/8	13/32	.396	11.16	5.93
4	9	8 3/4	7	3/4	6	11/16	7/16	.420	15.84	7.66
5	9 3/4	. .	8	3/4	6	3/4	7/16	.443	21.00	9.63
6	10 3/4	11	9 1/8	3/4	8	3/4	15/32	.466	26 64	11.82
8	13 1/4	. .	11 3/8	3/4	8	13/16	1/2	.511	39.36	16.91
10	15 1/4	15 1/2	13 1/4	3/4	10	7/8	9/16	.557	54.00	23.00
12	17 3/4	. .	15 3/4	7/8	12	15/16	19/32	.603	70.56	30.13
14	20	. .	18	7/8	14	1	21/32	.649	89.04	38.34
16	22	22 1/4	20	7/8	16	1 1/16	11/16	.695	109.44	47.70
18	24	24 1/2	22 1/4	7/8	16	1 1/8	3/4	.741	131.76	58.23
20	27	26 3/4	24 1/2	1	18	1 3/16	25/32	.787	156.00	70.00
22	28 3/4	29	26 1/2	1	20	1 1/4	27/32	.833	182.16	83.05
24	31 1/4	. .	28 3/4	1	22	1 5/16	7/8	.879	210.24	97.42
26	33 1/4	33 1/2	31	1	24	1 3/8	15/16	.925	240.24	113.18
28	35 1/2	35 3/4	33 1/4	1	24	1 7/16	31/32	.971	272.16	130.35
30	38	. .	35 1/2	1	26	1 9/16	1	1.017	306.00	149.00
32	40	40 1/4	37 1/2	1 1/8	28	1 5/8	1 1/16	1.063	341.76	169.17
34	42 1/4	. .	40	1 1/8	30	1 11/16	1 1/8	1.109	379.44	190.90
36	45	44 3/4	42	1 1/8	32	1 3/4	1 5/32	1.155	419.04	214.26
38	47	. .	44	1 1/8	32	1 13/16	1 3/16	1.201	460.56	239.27
40	49	49 1/4	46	1 1/8	34	1 7/8	1 1/4	1.247	504.00	266.00
42	51 1/4	51 1/2	48 1/4	1 1/8	34	1 15/16	1 5/16	1.293	549.36	294.49
44	53 1/2	. .	50 1/4	1 1/4	36	2	1 11/32	1.339	596.64	324.78
46	55 3/4	56	52 3/4	1 1/4	38	2 1/16	1 3/8	1.385	645.84	356.94
48	58	58 1/4	55	1 1/4	40	2 1/8	1 7/8	1.431	696.96	391.00

D = Diameter of Pipe.

FORMULÆ.—Thickness of Flange $= 0.033\ D + 0.56$.

Thickness of Pipe $= 0.023\ D + 0.327$.

Weight of Pipe per foot $= 0.24\ D^2 + 3\ D$.

Weight of Flange $= .001\ D^3 + 0.1\ D^2 + D + 2$.

Diameter of Flange $= 1.125\ D + 4.25$.

Diameter of Bolt Circle $= 1.092\ D + 2.566$.

Diameter of Bolt $= 0.011\ D + 0.73$.

Number of Bolts $= 0.78\ D + 2.56$.

NOTES AND COMMUNICATIONS.

WATER PURIFICATION BY MEANS OF IRON.

Business Meeting, April 19, 1890.—An illustrated paper on this subject was read by Mr. Easton Devonshire, Member Inst. C. E., England (visitor).

Sand filtration is frequently not sufficiently effective to insure a potable and hygienically pure water; and of the various methods of chemical purification most are not always harmless, and their cost generally precludes their adoption, except on a small scale.

The powerful purifying effect produced on water by metallic iron, recognized for many years, has led to attempts to apply it on the large scale for the supply of towns.

Until recently these methods have been based upon the principle of bringing the water into contact with the iron, either by letting it flow over plates or rods, or more generally by filtration through a layer of finely-divided granules of one or the other of the specially-prepared forms of the metal. Among the most successful of the latter is the so-called "spongy iron," patented some twenty-five years ago by Professor Bischof, and very extensively used in domestic filters.

The oxides of iron formed by the action of the metal on the water, added to the carbonates of lime precipitated, and to what may be called the products of the purification of the water, gradually filled up the interstices between the granules of the material, and prevented the water from passing through, except in variable and altogether insufficient quantities. Mr. Anderson finally hit upon that method of applying metallic iron to the purification of large volumes of water of which his Patent Revolving Iron Purifier is the outcome.

It was found that an experimental 4-inch revolving purifier, delivering 166 gallons per minute, and giving a contact of only 3½ minutes between iron and water, gave a better chemical result than one of the spongy iron filters giving a contact of three hours—both purified waters being afterward filtered by identically similar sand filters.

When used in revolving purifiers, waste or scrap iron, such as cast-iron borings or turnings and the burrs from punching machines, were as efficient as spongy iron, and were more suitable in form. A battery of revolving purifiers capable of dealing with 2,000,000 gallons per day, and contained in a building 31 feet long by 26 feet wide, the whole plant costing £4,000, as originally erected at the pumping station of the Antwerp Waterworks, has proved competent to do twice the work of three spongy-iron filters, having an area of 24,000 square feet, and the patent filtering material in which cost £8,000. The working expenses at the present time are also considerably less than formerly.

Description of the Apparatus.

The principle of Anderson's Revolving Iron Purifier consists in the production of an intimate contact between metallic iron and the water to be purified, by the showering down of finely-divided particles of the metal through an onward flowing stream of water.

The apparatus itself consists of a cylinder supported horizontally by hollow trunions revolving in pedestal bearings placed one at each end. Within the cylinder are a series of short curved shelves, arranged in steps at equal distances round its circumference and reaching from end to end. In the place of a sixth row of curved shelves is a line of small square plates, which can be set at an angle with the axis of the purifier. These plates direct the shower of iron back toward the inlet end of the apparatus, and counteract the tendency of the current to carry the purifying material forward. Through the hollow trunions pass the ends of inlet and outlet pipes. Facing the inlet pipe is a circular distributing plate secured at a distance of $\frac{5}{8}$-inch or $\frac{3}{4}$-inch from the end of the cylinder, serving to distribute the water radially on its entering the "revolver," and prevent its flowing in a direct current along the axis of the apparatus. The inner end of the outlet pipe is fitted with an inverted bell-mouth, carried down as near to the bottom of the cylinder as the shelves will allow, and intended to prevent the finer particles of iron from being carried out by the current of water. A rotary motion is given to the cylinder through gearing.

Iron in a moderately fine state of division is introduced into the cylinder and spread evenly along the bottom in sufficient quantity to occupy one-tenth of the capacity of the cylinder.

When the purifier is to be set in motion, the sluice-cock at the inlet is opened and the cylinder filled with water, the air being expelled through the air-cock, the speed of rotation being about 6 feet per minute at the periphery. By this rotary movement the shelves scoop up the iron granules, which, at starting, are spread evenly along the bottom of the cylinder and shower them down through the water. The flow of water may be regulated to the speed required to give the duration of contact with the iron found necessary for efficient purification under the particular circumstances.

On leaving the "revolver" the water requires to be aërated by exposure to the air, in order that the iron which has been dissolved may oxidize. For this purpose it is usually sufficient to allow the water to run along a shallow open trough direct on to the filter-beds, the water over the sand in which should be three or four feet deep, so that it might take some six hours in reaching the sand. A preferable arrangement, especially for bad water, is to deliver the contents of the revolvers into two or, better still, three settling ponds, each capable of holding six hours' supply, filling the ponds in succession, and decanting the water into the filter-beds by floating pipes from the surface. This arrangement prevents much of the impurities from settling on the surface of the sand in the filters, and so prolongs the time for which they will run without cleaning. With some waters, and especially those colored by peat, a great deal of aëration is necessary, in order to completely abolish color and opalescence; in such cases air must be injected by means of a blower or pump, arranged to deliver a stream of air into the open trough through a perforated false bottom. In the rare cases where this is insufficient, a solution of perchloride of iron or of some other salts, added in minute quantities, will probably produce the desired effect.

Full accounts of the details of the method of purification are to be found in various technical journals.

A NEW CONDENSING AND REFRIGERATING SYSTEM. CHALIGNY & GUYOT-SIMERST.

Regular Meeting, June 7, 1890.—The Secretary presented, for Mr. Strickland L. Kneass, the following notes:

The subject of an economical condensing apparatus for low-pressure engines, in which the condensing water can be used over and over again, is one that has often engaged the attention of inventors. Numerous mechanical devices have been tried, yet none have been found perfect enough to warrant more than experimental adoption.

The simplest method that would naturally suggest itself for the purpose is the use of storage tanks of sufficient capacity to permit a loss of heat by radiation between intervals of use, equal to that supplied by the steam. The large cooling reservoirs in use by some of the English mills are examples of this method of repeated use of the water. There are, however, objections in the cost of the basins, the increasing impurity of the water, and the great exposed area required for radiation and evaporation.

The cooling tower system, used in connection with the condensing apparatus of sugar refineries, has met with success in warm climates, and is extensively used on the plantations of Cuba. The tower is necessarily very high, and the additional power required to force the water to the top is very considerable. The water remains pure for a much longer period than with the other system, owing to its more perfect evaporation.

In one of the issues of the Bulletin of the Society for the Encouragement of French Industries occurs a description of a new system containing the good features of this last arrangement, and more general in its application. The apparatus was erected in connection with an engine of 30 horse-power, and a series of tests instituted by a Commission of Engineers of the Eastern R. R. of France to determine its efficiency.

The novelty of the scheme consists in the artificial aëration of the water of condensation, the cooling being effected by a current of air from a fan through a specially-designed refrigerating room.

The engine upon which the tests were made was arranged to exhaust freely into the air, or into the condensing apparatus, and tests of the consumption of coal and weight of water used were made in both cases. The saving in feed-water was noted as 39 per cent., while that in coal—the same quality being used in both experiments—was 35 per cent., reducing the fuel to 2 $\frac{38}{100}$ lbs. per H. P. per hour measured by brake.

The condensing apparatus was similar to the surface and jet condensers in ordinary use; the condensing water enters the jet condenser direct from the refrigerator, and is then forced by the pumps around the tubes of the surface condenser. The water, having performed its duty in the condensers and absorbed the full heat of the steam, passes to the refrigerating apparatus where its temperature is reduced to about 75 degrees before returning to be again used.

This refrigerator or regenerator, as the inventors call it, is a box-like room--dimensions not given—divided into parts by a large number of horizontal shelves, made up of twigs and small branches closely interwoven like a sieve; through these shelves the water percolates, falling into a shallow pan at the bottom; a centrifugal fan forces large volumes of air at a pressure of about $\frac{1}{10}$ inch water over the surface of the water and up through the dripping shelves, escaping from the top almost completely saturated with moisture and at a temperature of about 100 degrees.

The quantity of water required for an apparatus of this kind is claimed to be small, and the wastage due to evaporation in cooling amounts to less than the feed-water of a non-condensing engine of same size. As the number of heat units given out in the evaporation of one pound of water is 1,500, and the total heat to be extracted from one pound of steam at a tension of 20 inches vacuum is 1,100, it will be seen that the weight of water evaporated in restoring the condensing water to its original temperature ought to be less than the weight of steam used, or in other words the weight of water fed into the boiler, so that the condensation costs no water.

In conclusion, we may add that the system was commended by the board of examining engineers, who seemed to think the apparatus well designed and in shape for practical use, while the saving claimed by its inventors, Messrs. Guyot & Chaligny-Simerst, might lead to its adoption in places where the water supply is limited, and close economy of power a special consideration.

PLEA FOR A MONUMENT TO THE LATE JAMES B. EADS.

Business Meeting, June 21, 1890.—The Secretary presented a letter from Mr. E. L. Corthell, Active Member of the Club, inclosing a copy of an address made by him before the Western Society of Engineers, in behalf of a resolution to co-operate in erecting a monument to the late James B. Eads. The address reviews briefly Mr. Eads' career, his early struggles with poverty, his studies by night while engaged as clerk in a store, the years spent by him upon the Mississippi in his youth, the acquaintance he formed with the peculiarities of the river, and his devices for overcoming many of them.

The river was his university, from which he graduated at the age of 40 and just before the outbreak of the civil war, during which he was engaged chiefly in the construction of iron-clad vessels for the United States Government.

After the war followed the two great enterprises by which Eads' name is best known, viz., the building of the St. Louis bridge, and the opening of the South Pass of the Mississippi River by means of jetties.

The address concludes with an eloquent pen-portrait of Eads' character and abilities, and urges co-operation in the work of erecting a suitable monument to his memory.

INJURIOUS EFFECTS EXERTED BY GASES FROM LOCOMOTIVE SMOKE-STACKS UPON VEGETATION.

Regular Meeting, October 18, 1890.—The Secretary presented, for Mr. Robert A. Cummings, a photograph illustrating the injury to foliage caused by the gases escaping from the smoke-stacks of locomotives.

The photograph is a view looking along the main line of the Norfolk & Western Railway at Bedford, Va. A dozen large maple trees extend in a line parallel with the track, and about eight feet from it, and their limbs and foliage completely overhang the track. Apparently, the foliage, if uninjured, would just about have cleared the smoke-stacks, but the gases from the latter have cut a path though it about 6 feet wide at the bottom and 10 feet wide at the top, which is about 35 feet above the rails. The tapering form of the path is, no doubt, due to the spreading of the gases as they ascend. Beyond the track the foliage is uninjured. The locomotives burn local bituminous coal.

A NEW FEED RATCHET.

Regular Meeting, December 6, 1890.—Mr. Wilfred Lewis exhibited a working model of a patent friction catch recently invented by him, and applied by Messrs. Wm. Sellers & Co., Inc., to their planing machines. The device was intended to take the place of the reversible toothed ratchet commonly employed on the feed-rods and screws, and its special advantages were shown to consist in its superior

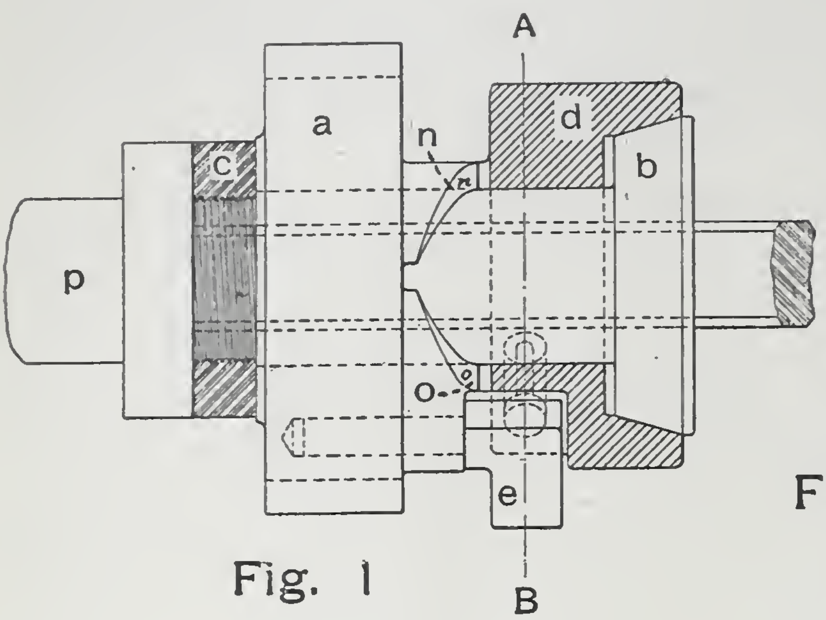


Fig. 1

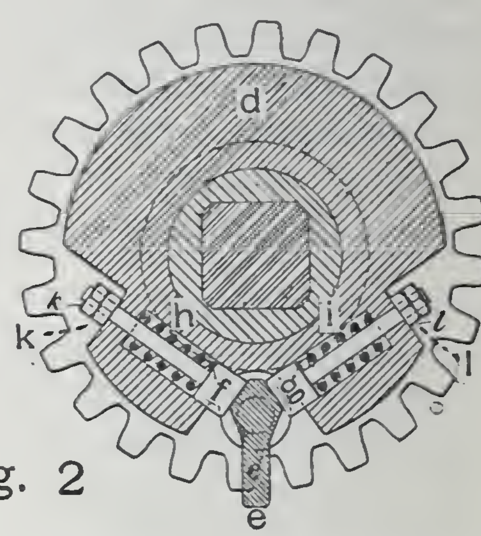


Fig. 2

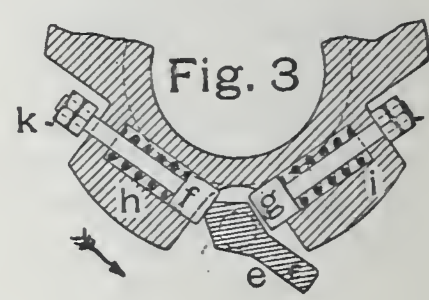


Fig. 3

strength and range of action. In the common form of ratchet the minimum arc of action is determined by the number of teeth, while in the new friction catch it can be reduced indefinitely to any desired amount. The same form of feeding-catch is used on other machines, and is available for any purpose to which a common ratchet has heretofore been applied.

The construction and operation of this feeding device can be understood by reference to the illustrations. Fig. 1 is a side view showing the engaging member *d* in section, and the right and left-hand helical cam faces *o* and *n* of the driver *a*. Fig. 2 is a section on the line *AB*, Fig. 1, showing the switch *e* in its middle or neutral position, and Fig. 3 shows the switch thrown over to feed in the direction indicated by the arrow. *a* is the cam-faced driver, having a reciprocating motion upon its axis. *b* is the driven member, having a coned surface at one end and the abutment collar *c* at the other. *d* is the engaging member between *a* and *b*, having right and left-hand cam faces fitting against the corresponding surfaces *o* and *n* on *a*, and a coned friction surface fitting against *b*. *e* is the switch turning in *a* and forming an abutment, against which the plungers *f* and *g* may act. *h* and *i* are springs actuating the plungers *f* and *g*. *k* and *l* are stops by which the movement of the plungers is limited. *p*

is the rod to which the device is required to impart motion. *a* and *d* fit loosely on the sleeve of *b*, and when the cam faces are in contact there is a slight amount of clearance between the collar *c* and the cone face of *b*. Now, if *a* be rotated in either direction relative to *b*, it is evident that this clearance will be taken up, and, if the motion be continued, *b* will be forced to turn with *a* and *d*. This is a necessary consequence, because the parts must be so proportioned that the moment of friction between the conical faces of *d* and *b* is greater than the driving moment between the helical faces of *a* and *d*. If, therefore, the engaging member is free to engage with the cam faces *o* and *n* on the driving member *a*, the driven member *b* will follow the reciprocating motion of the driver. On the other hand, if the engaging member is held in a central position relative to the driving member, no movement can result, and this relation is established by means of the switch *e* when set as shown in Fig. 2. When the switch is set as shown in Fig. 3, the plunger *f* is forced back by the end of the switch *e*, compressing the spring *h* and forcing the left-hand cam faces together. At the same time the switch is disconnected from the plunger *g*, and the force of its spring *i* is expended on the stop *l*. The left-hand cam faces being thus brought together by the action of the spring *h*, it is evident that when *a* moves in the direction indicated by the arrow, *d* and *b* will move with it. When the motion of the driving member is reversed, the engaging member is driven only by the spring *h*, and the pressure exerted therefrom on the conical surfaces of *d* and *b* being insufficient to drive the latter, the engaging member simply slips around without effect, as desired. When the switch *e* is turned in the opposite direction to that shown in Fig. 3, compressing the spring *i*, the right-hand cam faces will be brought in contact, and the catch will feed in the opposite direction.

SUBURBAN DEVELOPMENT.

Regular Meeting, December 20, 1890.—Mr. Edward Hurst Brown presented a paper upon the development of suburban settlements.

The paper notices the fact that the cultivation of a taste for semi-gregarious rural life on the part of dwellers in cities is one of recent growth, and traces its origin to the crowded condition and wide extent of our modern cities, together with the difficulty of intramural travel. Steam railways, by seizing the opportunity thus offered and encouraging suburban traffic, have created the modern suburban residence village.

The earliest refugees from the cities dwelt in comparative isolation, but this state of things naturally soon gave way to the establishment of suburban communities, small and few at first, but rapidly increasing in size, in number and in completeness of organization.

Unfortunately, however, the design of these settlements has been at the mercy of the speculators who have promoted them and who have too often been actuated solely or chiefly by the desire to place as many salable lots as possible upon the tract, to the prejudice of anything like a harmonious landscape effect in the whole, if not also to that of a well-matured system of water-supply and drainage.

The paper cites, as a notable exception to this lamentable state of affairs, the town of Wayne, fourteen miles from Philadelphia, the creation of Mr. George W. Childs.

Here the control of several hundred acres by one intelligent management has resulted in a picturesque design of the whole. An excellent water supply is obtained, partly from springs some distance from the town and partly from a large number of wells, driven in a lot specially reserved for the purpose and secured from contamination by an admirable system of drainage designed by Colonel Waring, to which every house and stable in the town is obliged to be attached, by an express stipulation in the deed. The entire sewage of the town is utilized upon a farm some two miles away. Electric light is supplied by a stock company, and there has recently been established, in South Wayne, a central steam-heating plant on the Holly system so successfully used at Williamsport.

The residents of North Wayne have formed an association, to which every respectable householder is eligible, for local self-government. The association meets monthly for the discussion of public matters. The dues are two dollars per month, and the money thus raised provides street lighting, policeman's salary, and the removal of ashes and garbage. A volunteer fire brigade is provided with a hand fire-engine and a hose-cart, and each member of the association is furnished with a horn, to be blown in case of fire or burglars, when the other members are obliged to come to his assistance.

SHINGLE FOR CONCRETE OR BETON.

Regular Meeting, December 20, 1890.---The Secretary presented, for Mr. Chas. H. Haswell, the following paper:

My consideration having been called to the practicability of using siliceous shingle for the manufacture of concrete or beton, in lieu of ordinary broken stone, I submit the following elements for consideration and my conclusion thereon.

It affords, in consequence of the absence of depressed faces, angular and pointed edges, more effective tamping in bedding than broken stone and a resulting increased solidity to the mass, combined with equal, irregular cleavage and greater cohesive strength and its resultant resistance to stress in any direction.

Beton, in a normal condition of adhesion and induration, ruptures alike through the cement and stone, and any increased resistance to the latter adds to the strength of the mass. Hence, as this shingle has greater transverse strength than ordinary stone, beton composed with it is stronger than if with stone.

The irregular faces and sharp edges of broken stone are not elements of advantage in the composition of either concrete or beton, as they in nowise contribute to the adhesion of the lime or cement with which they are mixed.

From an operation with pure shingle, made with the view of determining the volume of voids in a mass of it, I found their aggregate to be but .357 of it; hence shingle fills a greater proportionate volume of a mass of concrete or beton than broken stone, and effects thereby a small saving in cement and sand, without detracting from their strength.

I am of the opinion that shingle, in the condition and of the character examined, is superior to broken stone in the composition of concrete or beton, both in strength and economy of cost.

A NEW METHOD OF MAKING BARRELS.

REGULAR MEETING, OCTOBER 18, 1890.—Mr. Arthur Falkenau described a machine for making barrels, the invention of Mrs. M. E. Beasley. It is claimed that this machine differs radically from all others, not only in its details, but in its general conception, which is so entirely original as to involve a new method of manufacture. Many barrels are still made by hand, the crozing* and chamfering† being done with hand planes. The ordinary method of making barrels by machinery may be outlined as follows: The rough staves, rived, bucked or sawed,‡ but not crozed or chamfered, are received by the barrel manufacturer from the saw-mills of the lumber regions. The staves are then jointed§ in a special machine, and set up by hand in the form of a barrel, their lower ends being set in a circular frame called a jack, and secured by a truss-hoop,‖ while the upper ends flare outward by reason of the greater width of the staves between their ends. The upper ends of the staves are then drawn together by means of a windlass, the rope of which is made fast to a fixed point and passed around the staves, and are held in place by a truss-hoop. The barrel is then "fired;" *i. e.*, heated on the inside by a stove, in order to give the staves a permanent set in the shape to which they have been brought. The barrel is then placed in a machine having two disks, between which the barrel is compressed endwise, or "leveled," the ends of the staves being thus brought approximately flush with each other. It then passes to a trussing machine, where extra truss-hoops are firmly forced onto the barrel, after which it is passed to a machine performing the operations of sawing the ends to a uniform length, crozing and chamfering. The barrel is then completed by hand by the cooper, who puts in the heads, and smooths and hoops the barrel.

The new machine greatly simplifies the process, and in many respects reverses it. With it, the staves, received from the mill as before, are set up by hand in a circular "jack" frame; not (as before) as part of the manufacture proper, but merely as a measuring operation in order to determine how many staves will be required for the barrel. They are then placed, in sets, in boxes filled with steam, in order to make them more pliable, and then on the conveyor-chain of the machine, which carries them first to a centering device which brings the widest points of all the staves in line, and next between two circular saws which trim them off to a uniform length. Still carried by the conveyor-chain they next come to a pair of parallel rails running lengthwise of the machine and parallel to the travel of the staves. These rails, which slope gently upward, support the middle portion of the length of the staves, while their ends are held down by *horizontal* flanges on the side frames of the machine. The staves are thus bent to the proper curve. Toward the last, where the pressure between the staves and the flanges becomes considerable, the latter are furnished with

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* Crozing consists in cutting the notches on the insides of the staves near their ends, to receive the heads.

† Chamfering consists in beveling the inner edges of the ends of the staves. It facilitates putting the heads in place.

‡ These terms refer to the different methods of getting out the rough staves.

§ Their long edges beveled slightly to accommodate them to the circular section of the barrel.

‖ A frame consisting of two hoops, trussed together. It is placed over the staves temporarily, to hold them in barrel shape.

rollers. At this point the staves are crozed, howeled* (for tight barrels only) and chamfered, and their ends trimmed by saws and cutters forming part of the machine. They then leave the conveyor-chain and are pressed forward by a series of pushing-fingers to the setting-up chucks.

The heads are already in place in the chucks, where they are held in place by air pressure, a vacuum being produced behind them by means of pipes leading to a suction-fan; and the staves, pressed forward by the pushing-fingers, arrange themselve in barrel shape around it. When the chucks have thus received a full set of staves for a barrel, the feeding apparatus is stopped by means of a lever, which at the same time operates a series of cranks; and these, by means of pushing-rods, drive on the truss-hoops and thus close the barrel. The return stroke of the cranks draws the chucks apart, and thus releases the barrel, which drops out upon skids and rolls to the floor. Hooping, dressing and trussing out† are then done by hand.

A man can make by hand 30 to 40 slack barrels‡ a day and receive about 7 cents each in the East, and from 9 to 10 cents in the West. One Beasley machine will turn out 900 slack barrels a day, at a cost of about 3 cents each for the work. By the old method the work of making a tight barrel§ costs from 30 to 35 cents, whereas by the new method the cost is but from 12 to 15 cents. Inasmuch as Chicago consumes 30,000 barrels a day for pork and lard alone, it will be seen that this reduction of more than 50 per cent. in the cost of the labor is an important saving.

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* The howel is a groove, of rounded cross-section, which passes around the inside of a tight barrel near the ends of the staves. The croze extends from the summit or middle point of this groove.

† Owing to the friction between the edges of adjoining staves, some of them frequently remain projecting beyond the normal curve of the barrel, while others remain too far in. Trussing out and dressing consist in forcing out the latter and adzing down the former.

‡ Barrels for holding dry substances.

§ Barrels for liquids, lard, etc.

ABSTRACT OF MINUTES OF MEETINGS.

Of the Club.

April 4, 1891.—Regular Meeting.—President Wilfred Lewis in the chair; 29 members and one visitor present.

The minutes of Regular Meeting, March 21, 1891, were approved.

The Secretary announced that the courtesies of the Club House would be extended to the American Water Works Association during their coming meeting in Philadelphia.

Prof. H. W. Spangler and Messrs. John C. Trautwine, Jr., C. Henry Roney, and Wilfred Lewis discussed the discharge of steam, etc., from boilers.

Mr. Thomas G. Janvier read a paper on "The Engineering Features of the Road Question."

The paper was discussed by Mr. C. H. Ott.

Mr. E. V. d'Invilliers, by request of the author, Mr. C. R. Claghorn, of Birmingham, Ala., presented a paper entitled "An Economical Review of the Alabama Coal Fields," which was discussed by Mr. Samuel R. Marshall.

April 18, 1891.—Business Meeting.—President Wilfred Lewis in the chair; 25 members and one visitor present.

The minutes of Business Meeting, March 7, 1891, were approved.

The President brought before the meeting the question of the incorporation of the Club, and the Secretary read the following abstract from the minutes of the Board Meeting, held this afternoon:

"On motion of Professor Spangler, it was ordered that the Board unanimously recommend to the meeting to-night that the Club authorize the Board to take such steps as may be necessary to effect the incorporation of the Club."

Mr. T. Carpenter Smith stated that he had learned that the cost of incorporation would probably not be over $50, and in no event would be likely to exceed $100.

On motion of Mr. Henry G. Morris, it was unanimously ordered that the Officers of the Club be directed to carry out the recommendation of the Board of Directors.

The Tellers of Election, Messrs. Geo. T. Gwilliam, Andrew H. Haig and C. H. Ott, reported that 85 votes had been cast, and that the following gentlemen had been elected members of the Club:

Active Members: Messrs. J. Clarence Ogden, John S. DeHart, Jr., Chas. B. Colby, C. Louis E. Amet, Hermann S. Hering, Albert R. Cline, J. Adelbert Patton, Wm. H. Boardman and Fred. C. Dunlap.

Associate Member: Mr. David S. B. Chew.

The report of the Tellers was accepted.

Mr. John C. Trautwine, Jr., presented, for Captain S. C. McCorkle, a paper on Land-locked Navigation from Long Island Sound to the Mississippi River, with blackboard maps of the portion of the route from the Suwanee River, Fla., to New Orleans.

May 2, 1891. — Regular Meeting. — Vice-President David Townsend in the chair; 17 members and one visitor present.

The minutes of Regular Meeting, April 4, 1891, were approved.

The Secretary presented, for Mr. George R. Ide, a paper descriptive of the Judson Pneumatic System for Street Railways as constructed and operated at Washington, D. C.

The Secretary announced, for the Committee on Information and Entertainment, that special papers on the subject of Rapid Transit would be presented at the next meeting of the Club on May 16, 1891.

May 16, 1891.—Regular Meeting.—President Wilfred Lewis in the chair; 56 members and five visitors present.

The Minutes of Regular Meeting, May 2, 1891, were approved.

Papers upon Rapid Transit and kindred subjects by Professor H. W. Spangler, Mr. G. Herbert Condict (visitor), and Mr. T. Carpenter Smith were read. They were discussed by Messrs. P. G. Salom, T. Carpenter Smith and Henry B. Seaman.

The Secretary presented, for Mr. Samuel L. Smedley, a plan and profile of Market Street. Mr. Smedley also forwarded two photo-

graphs of the same point in the line of an elevated railway in New York; one taken at about the time of construction, showing little in the vicinity but vacant building lots and a few shanties; the other taken ten years later and showing lines of fine buildings on both sides of the street.

Mr. Smedley also presented a copy of specifications and proposals for building and operating an elevated railroad on Market Street.

June 6, 1891.—Regular Meeting.—President Wilfred Lewis in the chair; 33 members and three visitors present.

The Secretary presented for the information of the Club several communications with regard to the proposed Engineering Congress and Headquarters at the Columbian Exposition in Chicago in 1893.

The Secretary presented, for Mr. G. W. Creighton, a continuation of a paper previously presented by him upon the subject of Rail Joints, giving the results of experiments which had been made since the presentation of the original paper.

Professor H. W. Spangler described an experiment in tension with a cast-iron bar, 15 inches long, of a uniform thickness of $\frac{7}{8}$ inch, but of varying width. The width was 1 inch at the ends, but abruptly increased to $1\frac{1}{2}$ inches at a point 5 inches from one end, and to 3 inches at a point near the middle, and again reduced to 1 inch at 5 inches from the other end. Under tension the bar had broken, not at the 1-inch, but at the $1\frac{1}{2}$-inch section. Prof. Spangler demonstrated briefly that this was in accordance with theory, since the line of resultant stress, being in the center of the 1-inch section, passed through the $1\frac{1}{2}$-inch section at one-third of its width from one side, thus causing a maximum fiber stress at that side.

The subject was discussed by Mr. C. Barth, visitor, and by Mr. John L. Gill, Jr.

June 20, 1891. — Business Meeting. — Vice-President David Townsend in the chair; 26 members and one visitor present.

The Minutes of Business Meeting, April 18, 1891, were approved.

The Membership Committee reported that three of the mem-

bers who had been urged to withdraw their resignations had consented to do so. The Committee recommended that the resignations of Messrs. R. H. Soule, A. W. Sims, E. A. Rhoads, Charles W. Pusey, J. D. Newbold, Mansfield Merriman, Robert P. Field and Percival Roberts, Sr., be accepted, which was so ordered.

The Secretary read a report upon the matter of the International Engineering Congress and Engineering Headquarters which it is proposed to hold at the proposed World's Columbian Exhibition, in Chicago, in 1893. Upon motion of Professor H. W. Spangler, the action of the General Committee was approved.

The Secretary presented a report on the matter of the incorporation of the Club. Through the kind professional attention of A. J. Rudderow, Esq., Associate Member of the Club, the charter has been prepared, engrossed, and properly signed.

The Secretary presented, for Mr. Charles S. Churchill, a paper on "Rail Joints," with plans, showing a rail joint devised by Mr. Churchill over a year ago, which has been on trial for the past year on the Norfolk and Western Railroad.

Another drawing showed a modification of this joint in which all the parts are so designed that they can be more readily manufactured.

Professor H. W. Spangler presented a description of the testing of the accuracy of Steam Gauges.

Mr. John C. Trautwine, Jr., compared Mr. Churchill's rail joints with those proposed in a recent paper by Mr. George W. Creighton.

Mr. Trautwine, for the Publication Committee, announced that the next number of the Proceedings, Vol. VIII, No. 1, was now in press, and would be issued about July 1st, and that the Committee was making every effort to bring the publication up to date.

Mr. John E. Codman reported for the tellers of election that seventy-five legal votes had been cast, and that the following had been elected Active Members of the Club: Messrs. James McCann, S. W. Putnam, Neville B. Craig, D. W. Taylor, John Overn, Abm. Bruner, Charles L. Prince, John V. W. Reynders, Frederick Bloch, O. M. Weand, William J. Smith, Henry Howson, George McCall, George L. Van Zandt, W. W. Stevens, Clarence M. Du-

Bois; and that Mr. Albert Priestman had been elected an Associate Member of the Club.

Of the Board of Directors.

April 4, 1891.—Special Meeting.—President Wilfred Lewis in the chair.

Present—Messrs. Townsend, Salom, Trautwine, F. H. Lewis, Spangler and Webster; also Mr. T. Carpenter Smith, Treasurer.

Reports from the House, Finance and Publication Committees were read and accepted.

On motion of Mr. Townsend it was ordered that the incorporation of the Club be recommended to the Club at its next business meeting.

It was ordered that the House Committee be authorized to make expenditures during the current year to an amount not exceeding nine hundred dollars; that the Board extend the courtesies of the Club to the American Water Works Association at their coming meeting; and that the Secretary be authorized to procure forms for blanks, etc., as recommended by the Publication Committee.

April 18, 1891.—Regular Meeting.—President Wilfred Lewis in the chair.

Present—Messrs. Townsend, Spangler, Hering, Salom, Trautwine and F. H. Lewis.

On motion of Mr. Salom the salary of the Secretary was made fifty dollars per month from May 1st, 1891, and that of the Treasurer, ten dollars per month from April 1st.

On motion of Prof. Spangler it was ordered that the price of the Proceedings be reduced to two dollars per annual volume of four numbers; also, that the advertising rate for the fourth page cover of the Proceedings be referred to the Publication Committee, with power to act.

Mr. Townsend announced the receipt of replies from three of the members who had presented their resignations, and who had been urged to withdraw them. One of the three had consented to do so, but the other two insisted upon the presentation of their resignations.

On motion of Prof. Spangler it was ordered that the Board unanimously recommend to the meeting this evening that the Club authorize the Board to take such steps as may be necessary to effect the incorporation of the Club.

On motion of Mr. Salom it was ordered that the Treasurer be required to make a report to the Board at each of its regular monthly meetings, said report to include the previous monthly balance and the receipts and expenditures for the month.

April 28, 1891.—Special Meeting.—President Wilfred Lewis in the chair.

Present—Messrs. Townsend, Trautwine, Salom and Spangler; also, Mr. T. Carpenter Smith, Treasurer, and A. J. Rudderow, Esq., Attorney-at-Law, Associate Member of the Club.

The Secretary reported the action of the Business Meeting of the Club, on April 18th, 1891, unanimously ordering that the officers of the Club be directed to take such steps as may be necessary to effect its incorporation.

A. J. Rudderow, Esq., then stated the requirements of the law, with regard to the matter of our incorporation, and answered various questions which were submitted to him.

On motion of Prof. H. W. Spangler it was ordered that Mr. Rudderow be requested to draw up a charter and present the same to the Board for its consideration at a Special Meeting to be held on Saturday, May 2, 1891, at 4.30 o'clock, P.M.

Mr. David Townsend presented communications from two members of the Club who had presented their resignations. One of these members withdrew his resignation, and the other declined to do so.

The Treasurer presented a statement of his accounts.

The President announced the appointment of Mr. John W. Cloud as the representative of the Club on the permanent Committee on International Engineering Congress and Engineering Headquarters at the coming World's Fair at Chicago.

May 2, 1891.—Special Meeting.—President Wilfred Lewis in the chair. Present, Messrs. Townsend, Hering, Salom, Spangler, Trautwine and Webster; also, Mr. T. Carpenter Smith, Treasurer, and A. J. Rudderow, Esq.

Mr. Rudderow presented a draft which he had prepared for the charter of the Club. After considerable discussion and slight amendment it was ordered that Mr. Rudderow be authorized to apply to Court for the charter as made and amended, and that the present officers of the Club sign the charter.

A vote of thanks was unanimously tendered to Mr. Rudderow for his professional services in the matter of the charter.

MAY 16, 1891.—President Wilfred Lewis was present, with Messrs. F. H. Lewis, Trautwine and Webster; also, Mr. T. Carpenter Smith, Treasurer.

No quorum.

JUNE 11, 1891.—President Wilfred Lewis in the chair. Present, Messrs. Townsend, Spangler, F. H. Lewis, Hering and Trautwine; also, Mr. T. Carpenter Smith.

The Treasurer made an informal report upon the condition of the Treasury.

On motion of Prof. Spangler it was ordered that the furnishing fund balance in the Treasury be applied to payment for the desk and letter boxes in the lower hall.

It was ordered that the President appoint a special committee of the Board to endeavor to complete the sum of $500 which the Club desired to raise as its contribution toward the fund for the proposed Engineering Congress and Headquarters at the Columbian Exposition in Chicago in 1893.

The President subsequently appointed the following Committee, Prof. Spangler and Messrs. Trautwine and Townsend.

On motion of Mr. Townsend, it was ordered that the tellers appointed by the President be made tellers to conduct such elections as may occur for the remainder of this year. Messrs. Strickland L. Kneass, L. F. Rondinella and M. R. Mucklé, Jr., are the tellers. Mr. John E. Codman was named as alternate, and another alternate was ordered to be appointed by the President, who, after the meeting, named Mr. Arthur Falkenau for this office.

JUNE 20, 1891.—Present, Messrs. Townsend, Spangler and Trautwine.

No quorum.

CONTRIBUTIONS TO THE LIBRARY.

From January 22, 1891, to June 29, 1891.

From the INSTITUTION OF CIVIL ENGINEERS, London, England.
Pole—Mental Calculation.
McLaren—Steam on Common Roads.
More—Tramway Permanent Way.
Hall—Failure of the Limerick Dock Walls.
James—Timber in the Tropics.
Kinder—Railways and Collieries of North China.
Abstracts of Papers in Foreign Transactions and Periodicals. Vols. CIII, CIV.
Maclean—Sidhnai Canal System.
Moyle—Conversion of Metre Gauge to Indian Standard Gauge.
Sadler—Flow of Water in Earthen Channels.
Sheibner—Carrara Marble District Railway.
Milne and McDonald—Vibratory Movements of Locomotives.
Stevenson—Gas Supply of Buenos Ayres.
Sykes—Rao Shri Pragmalji Bridge,Mandvi Kutch.
Robertson and Stoney—Indian Bridges.
Thurston—Authorities on the Steam-Jacket.
Spencer—Machine Stoking.
Capper—Development of the Port of Swansea.
Allen—Auxiliary Engines in Connection with the Modern Marine Engine.
Dwelshauvers-Dery—Steam Engine Governors.
Higgins—Von Schmidt Dredge.
Martens—Influence of Heat on the Strength of Iron.

From the NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS, Newcastle-upon-Tyne, Eng.
Report of the French Commission on the Use of Explosives in the Presence of Fire-Damp in Mines—Part III and last, March, 1891.
Transactions—Vol. XXXIX, Parts 1 and 2, 1891. Vol. XL, Part 1, 1891.

From the SOCIETY OF CIVIL ENGINEERS, Paris, France.
Mémoires—January, February, March.
Annuaire de 1891.

From L'ADMINISTRATION DES PONTS ET CHAUSSÉES, Paris, France.
Annales—January, February, March, April, 1891.
Personnel, 1891.

From the AUSTRIAN SOCIETY OF ENGINEERS AND ARCHITECTS.
Wochenschrift.
Zeitschrift—Part 1, 1891.

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Norsk Teknisk Tidsskrift—Parts 1 and 2, 1891.

From the SWEDISH SOCIETY OF CIVIL ENGINEERS.
Proceedings—Tredje Häftet. Fjerde Häftet, 1890.

From the PORTUGUESE SOCIETY OF CIVIL ENGINEERS, Lisbon.
Revista de Obras Publicas e Minas—Jan.-Feb., March-April, May-June, 1891.

From the ARGENTINE SCIENTIFIC SOCIETY, Buenos Aires.
Anales—January, February, March, April, May, 1891.

From the MINISTERO DEI LAVORI PUBBLICI, Rome, Italy.
Giornale del Genio Civile—January, February-March-April, 1891.

From the ENGINEERING ASSOCIATION OF NEW SOUTH WALES, Sydney, Australia.
Proceedings—Vol. IV. 1888-89. Bound.

From the CANADIAN SOCIETY OF CIVIL ENGINEERS, Montreal, Canada.
Transactions—October to December, 1890.
Charter, By-Laws and List of Members. 1891.

From the AMERICAN SOCIETY OF CIVIL ENGINEERS, New York.
Transactions—January, February, March, April, 1891.

From the AMERICAN INSTITUTE OF MINING ENGINEERS, New York.
Transactions—Advance Sheets.

From the ASSOCIATION OF ENGINEERING SOCIETIES, New York.
Journal—January, February, March, April, May, 1891, Index—Annual Summary, to be bound with Vol. IX, 1890.

From the AMERICAN IRON AND STEEL ASSOCIATION, Philadelphia.
The Bulletin.
Annual Statistical Report, Presented to Member April 15th, 1891.

From the ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA, Pittsburgh, Pa.
Transactions—Advance Sheets. 1890–91.
Final Report of Committee on Roads, with Draft of Proposed Act, January 20th, 1891.
Proceedings—Vol. VI. Bound.
Charter and By-Laws.

From the AMERICAN PHILOSOPHICAL SOCIETY, Philadelphia.
Proceedings—No. 134, 1890; No. 135, 1891.

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Transactions—Vol. X, No. 1. 1890–91.

From the AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, New York.
Transactions—December, 1890; January–February, March, April, May, 1891.

From the STEVENS INSTITUTE OF TECHNOLOGY, Hoboken, N. J.
The Stevens Indicator.

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Transactions—September–January, 1890–1891.

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From the VANDERBILT UNIVERSITY, ENGINEERING DEPARTMENT, Nashville, Tenn.
Proposed Tennessee Highway Law.

From the ALABAMA INDUSTRIAL AND SCIENTIFIC SOCIETY, Tuscaloosa, University P. O., Ala.
Proceedings—Vol. 1, No. 1, 1891.

From the FRANKLIN INSTITUTE, Philadelphia.
Journal—January, February, March, April, May, June, 1891.

From the BOSTON PUBLIC LIBRARY, Boston, Mass.
Bulletin—January, April, 1891.
Thirty-ninth Annual Report—1890.

From the LIBRARY COMPANY OF PHILADELPHIA.
Bulletin—March, 1891.

From the AMERICAN BANKERS' ASSOCIATION, Mr. Morton McMichael, President, Philadelphia.
Address of Edmund J. James, Ph.D., before the Convention held at Saratoga, September 3, 1890.

From the PENNSYLVANIA RAILROAD COMPANY.
Record of Transportation Lines for year ending December 31, 1890.

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Bulletins No. 3, December, 1890; No. 4, February, 1891.
Biennial Report of State Geologist to Thirty-sixth General Assembly, January 22, 1891.

From the ENGINEER DEPARTMENT, U. S. A., Washington, D.C.
Annual Report of Chief of Engineers, 1890, in four parts. Bound.

From the U. S. NAVY DEPARTMENT, Washington, D.C.
Pilot Chart of North Atlantic Ocean for February, March, April, May, June, 1891.
Proceedings—Naval Institute—Vol. XVI, No. 5, 1890; Vol. XVII, No. 1, 1891; Vol. XVII, No. 2, 1891.

From the U. S. COAST and GEODETIC SURVEY, Washington, D.C.
Report, 1888. Bound.
Catalogue of Charts and other Publications, 1890.
Bulletins, Nos. 19, 20, 21, 23.

From the SMITHSONIAN INSTITUTION, Washington, D.C.
Annual Reports, 1888, 1889. Bound.

From the INTERSTATE COMMERCE COMMISSION, Mr. Martin A. Knapp, Commissioner, Washington, D.C.
Fourth Annual Report, 1890. Bound.

From the SECRETARY U. S. BOARD on GEOGRAPHIC NAMES, Hydrographic Office, Navy Department, Washington, D.C.
Bulletin No. 2, issued May 25, 1891.

From the GEOLOGICAL SURVEY of PENNSYLVANIA, Office 907 Walnut Street, Philadelphia.
New General Map of the Anthracite Region. Revised to date, 1890. Bound.

From MR. R. MEADE BACHE, 4400 Sansom Street, Philadelphia.
Possible Sterilization of City Water—Read before the American Philosophical Society, April 17, 1891.

From MESSRS. ANDERSON & BARR, 240 Eleventh Street, Jersey City, N. J.
The Washington Bridge, Harlem River, New York City. 1891. Bound.

From MR. L. E. COOLEY, C. E., Chicago, Ill.
The Lakes and Gulf Waterway as related to the Chicago Sanitary Problem.

From MR. GEO. T. HUGHES, Clerk of Board of Public Works, City of Duluth, Minn.
Fourth Annual Report of Board of Public Works, City of Duluth, Minn., for year ending February 28, 1891.

From the HARBOR COMMISSIONERS of MONTREAL, Mr. John Kennedy, Chief Engineer.
Annual Reports for year 1890.

From the NICARAGUA CANAL CONSTRUCTION CO., Mr. Warner Miller, President, 44 Wall Street, New York.
Report on Prospective Tonnage of Traffic, 1890.
An Account of Surveys, etc., of Canal from 1502 to the present time.

From SAMUEL C. PERKINS, ESQ., President of the Commissioners for the Erection of the Public Buildings, Philadelphia.
Proceedings—Opening of New Rooms of Supreme Court of Pennsylvania in City Hall, Philadelphia, January 5, 1891.
Proceedings—February and March, 1891, in the Legislature of Pennsylvania, and in the City Councils of Philadelphia, for Repeal of Modification of Act of August 5, 1870, known as "Public Buildings Act."
Reports of Committee on Fitting up and Furnishing Rooms, of Progress made since Reports of July 3, 1889.

From MR. ERNEST PONTZEN, Civil Engineer, 89 Rue St. Lazare, Paris, France.
Procédés Généraux de Construction. Travaux de Terrassement, Tunnels, Dragages et Dérochements. 1891.

From MR. FREDERIC P. STEARNS, Chief Engineer of State Board of Health, Massachusetts, 13 Beacon Street, Boston, Mass.
Part I of Report on Water Supply and Sewerage, 1890. Bound.
Part II, of Report on Water Supply and Sewerage, 1890. Bound.

From the Author, MR. E. V. d'INVILLIERS, Active Member of the Club.
Phosphate Deposits of the Island of Navassa, January, 1891.

From MR. RUDOLPH HERING, Civil Engineer, Active Member of the Club.
Reports on The Sewerage and Water Supply for Atlanta, Ga. 1891.

From MR. PERCY T. OSBORNE, Active Member of the Club.
Lithograph Map of Rivermont Bridge, Lynchburg, Va. 1890.

From the Author, PROF. J. W. REDWAY, Active Member of the Club.
Climate and the Gulf Stream.
The Physical Geography of the United States, 1890.

1879.

1889.

Ninth Ave., New York City, looking North from 89th St., in 1879 and in 1889.

See pages 270 and 275.

PROCEEDINGS

OF THE

ENGINEERS' CLUB OF PHILADELPHIA.

ORGANIZED DECEMBER 17, 1877.

NOTE.—The Club, as a body, is not responsible for the statements and opinions ad-

In the Club Proceedings for April, 1891, Vol. VIII, No. 2, appeared an article describing the Lobnitz System of Demolishing Rock under Water without the Use of Explosives, translated by Mr. Edwin S. Crawley from *Nouvelles Annales de la Construction*, in which it appeared as an original article. Mr. Crawley has since learned that the paper was originally published in the Proceedings of the Institution of Civil Engineers, Vol. XCVII.

had to be defined by targets. These lines were all made to pass through a church steeple in Arkansas City, which therefore formed a target on each of these range lines. The other target on each line was then set between the steeple and the section, some on the levee, and others on the roof of a building situated between the levee and the river.

Velocities were taken, where these lines intersected the line of the section, by a current meter, lowered from a steamboat to a depth below the surface equal to six-tenths of the total depth of

1889.

Ninth Ave., New York City, looking North from 89th St., in 1879 and in 1889.

See pages 270 and 275.

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Vol. VIII.] OCTOBER, 1891. [No. 4.

XXI.

NOTES ON SOME MISSISSIPPI-RIVER-DISCHARGE OBSERVATIONS.

By JOHN J. HOOPES, Active Member of the Club.

Read March 7, 1891.

THE observations referred to in these notes were made in the vicinity of Arkansas City, Ark., during the flood of 1890. They extended over a period of five or six weeks, beginning about the middle of March.

The same discharge section was used that had been used in previous years, but the old ranges had been destroyed. Lines to intersect the line of the section, at points 300 feet apart, had to be defined by targets. These lines were all made to pass through a church steeple in Arkansas City, which therefore formed a target on each of these range lines. The other target on each line was then set between the steeple and the section, some on the levee, and others on the roof of a building situated between the levee and the river.

Velocities were taken, where these lines intersected the line of the section, by a current meter, lowered from a steamboat to a depth below the surface equal to six-tenths of the total depth of

the water at that point, this being the depth at which an average velocity is found. Each revolution of the wheel of the meter was indicated to the party on board by an electrical apparatus. The relation between the number of revolutions per second of the meter-wheel and the velocity of the water is determined from time to time by special observations. The positions of the soundings from which the areas of the several divisions of the section were obtained were determined by a transit over a point 2,000 feet above the section.

The river was several feet higher than the banks, and the water passing between the channel and the levee on each side was gauged separately. The velocities and soundings were taken on the same straight line as those in the channel, and their positions determined by stadia measurements. Surface floats were used in getting the velocities.

On the Mississippi side of the river there were three large crevasses in the levee above the discharge section and one below it. The largest of these was on the upper side of Catfish Point. On the lower side of the same point ten crevasses occurred, through which the flow was back into the river. The Catfish Point and Huntington crevasses (the two largest in the vicinity) were measured in the same manner as the river channel, except that equidistant points could not be selected for the velocity stations. Flags were tied to trees or bushes at points through which it was supposed, before measuring, that range lines could be passed to intersect the line of the crevasse at approximately equal distances apart. The positions of these flags were then determined from a base line on the levee. A plat was prepared showing the position of these points and of the crevasse, etc., and range lines passing through these flag points were platted thereon. The plat was used as a guide in the observations, and the positions of the velocity stations were scaled from it.

The velocities in the other crevasses were measured by timing surface floats; some while floating between lines of measured distances apart, and others while passing a skiff held stationary by a man in the bow, with a rope encircling a tree. The lines of section were on the line of some of the crevasses, above and parallel to others, and curved around others, keeping as nearly

DISCHARGE OBSERVATIONS
on the
MISSISSIPPI RIVER
in the vicinity of
ARKANSAS CITY, ARK.
1890

SCALE ½ 1 2 3 4 5 MILES

normal to the flow of the water as possible. The direction of the line of the skiff was often taken by a small compass to indicate the direction of the flow of the water, and where this was not normal to the line on which the velocities were taken they were correspondingly reduced.

On the Arkansas side of the river were six crevasses* above the discharge section, and water flowing around the end of the levee seventeen miles north of Arkansas City. This overflow had to pass through and over the embankment on the first seven miles of the railroad to Little Rock. Its discharge was therefore measured along the line of this railroad. The grade of the railroad was in many places above the height of the overflow, and in others very little below it. In the latter case the flow was regarded as being over a weir. There were about sixteen openings, some of them under trestling, and others where the embankment had been damaged. In measuring these the same methods were used as in measuring the crevasses.

The greatest crevasse was on the upper side of Catfish Point. It was 1,969 feet long, and its discharge 208,000 cubic feet per second. The ten crevasses on the lower side of Catfish Point aggregated about 3,000 feet in length, and through them 110,000 cubic feet per second flowed back into the river. The deepest sounding in any of the crevasses was 75 feet and in the river 91 feet. The width between the tops of the banks of the river on the discharge section is about 3,400 feet.

The maximum discharge was, in round numbers, about as follows:

River channel	1,350,000	cubic feet per second.
Overflow on left bank .	250,000	" " " "
" " right " .	150,000	" " " "
Total .	1,750,000	" " " "

* Including the one at Boggy Bayou, caused by a malicious cutting of the levee.

XXII.

AN IRON SEWER TEMPLET.

By H. B. Hirsh, Active Member of the Club.

Read March 21, 1891.

During the past Fall the writer had occasion to make, for the town corporation of Middlesborough, Ky., under the direction of Mr. Geo. E. Waring, Jr., of Newport, R. I., four sets of iron sewer templets, and it is the purpose of this paper to describe the construction of these templets and the method of using them.

As nearly as I can learn, the sewers pass through a liver-like stratum. The invert was built in a deep trench, closely sheet-piled and heavily braced. The nature of the soil gave considerable trouble and at times made the work very expensive. It was some time before the right method of tamping behind the templets was secured, but the greatest difficulty was to establish a good concrete back in such ground. After some time the tamping was so regulated that the templet could be moved immediately and without waiting for the beton to set.

Each templet was a little over 10 feet long, and consisted of a frame (Fig. 1*), made of three U-shaped ribs *U* of T-iron placed parallel with each other—one rib at each end and one in the middle of the 10-foot section. The ribs were fastened together at the top by two longitudinal angle irons, *A A*, Figs. 1 and 2, riveted to the outside of the T-irons of the *U* rib. The ribs were further connected together by a floor consisting of two pieces of sheet steel, $\frac{1}{8}$ inch thick, placed end to end, with the rib of the center T-rib between; each piece 5 feet long and 22 inches wide, curved to form troughs corresponding with the bottom of the *U* curve of the ribs. Each trough was riveted at each end to the flanges of the T-iron ribs. These troughs were strengthened by three small bars of channel iron to each trough, running longitudinally (one at each edge and one in the middle), and riveted to the concave surface of the troughs. Across the top of each *U*

* Fig. 1, copied from a hasty sketch, merely indicates roughly the general arrangement. For all details, see Figs. 2 to 6.

was placed a channel bar, T, 4 feet 6 inches long, which was riveted to the U by means of angle knees, as shown in Fig. 3, while its projecting ends rested upon the ground on each side of the ditch and supported the templet in place. So much for the frame.

The sides of the templet were made of movable bars of channel iron, S S, 5 feet long each, placed ten on each side in five rows. The bottom one of these channel bars on each side of the frame rested upon one of the small channel bars C (used for strengthening the trough or floor F), and supported the four similar bars above it. This provided for their *weight;* but it was, of course, necessary also to secure them to the ribs U against the inward pressure of the backing outside. For this purpose (see Fig. 5), one end of each channel bar S was secured to the central rib U by bolts, as indicated in Fig. 4 and on the left of Fig. 2, while their other ends were held to the end ribs U by the angle bars F, which were riveted to the web of the rib, as shown on the right of Fig. 2. As shown in Fig. 4, one bolt through the middle rib served to hold two channel bars S S against the central rib U. It passed through two staples riveted to one of the two channels and through the web of the rib; and its projecting end, by bearing against the web of the other channel, prevented its end from being pushed away from the rib. The bolts were prevented from falling out, when not in use, by the small stop shown at the right in Fig. 4.

The holes in the rib, through which these bolts pass, were drilled exactly, and the bolts attached to the movable channels with accuracy, so that all of the movable channels are interchangeable.

The templets are thus used: After the ditch has been dug and the bottom roughly filled and shaped with broken stone and mortar, the empty frame is lowered into the ditch until suspended by the cross-beams of channel iron T, which rest upon the ground on each side of the ditch. Then the space between the bottom of the ditch and the sheet-steel floor F of the frame is filled with cement and rammed hard. One of the movable side channels S is then bolted into the frame (see Fig. 4) on each side, and the space between this and the side of the ditch is filled with cement

and rammed. When this space is full, another channel bar *S* is bolted on above the one just finished and more cement filled in behind it, and so on until all the channels are in place and the wall of the sewer is built to the proper height, when the work is left to harden, while another templet adjoining the first is placed in position in the ditch and the process repeated there. By this time the portion of the sewer first built will have set, and the movable sides can then be unbolted and taken out, and the frame removed to a point lower down the ditch, where the operation is repeated. When the sewer is finished, the little inaccuracies and uneven places left by the templet are smoothed with a trowel by hand. Two templets of the above description were used. They weighed 1,280 lbs. each complete. This was made up of the frame, 600 lbs., and 20 movable channels, 680 lbs. It was found on the work that they were too heavy and that a good deal of time was lost in moving them, so that in making up the second pair it was decided to lighten them. Instead of five 5-inch channel bars *S* for the movable sides, four 3-inch channels were used at the bottom or next to the fixed steel plate, and three 5-inch channels above these. The bolt holes in the *U* rib were, of course, made accordingly. The U-shaped T-ribs were changed from 3 x 4-inch to $2\frac{1}{4}$ x $2\frac{1}{4}$-inch T, and instead of a 1 x 1-inch angle-bar guide, *F*, on the end ones, a $\frac{5}{8}$-inch square guide *G* was substituted, and a portion of the web of the channels *S* cut away, as in Fig. 6. The stiffeners for the sheet-steel bottom were reduced from 3-inch to $1\frac{3}{4}$-inch channels, and the plates from 22 to $17\frac{1}{2}$ inches in width. By means of these changes the weight of each templet (including the movable sides *S*) was reduced from 1,280 to 1,120 lbs., a saving of 160 lbs., although the number of pieces belonging to each templet was increased from twenty to twenty-eight.

The weight of the frame (600 lbs., without the movable sides *S*) would require six or seven men to handle and move it, and unless they could be employed on other parts of the work, they would add considerably to the cost. The expense of getting up a templet of this kind was between $80 and $90.

The materials consumed upon the sewer where these templets were employed were as follows per 100 feet of its length :*

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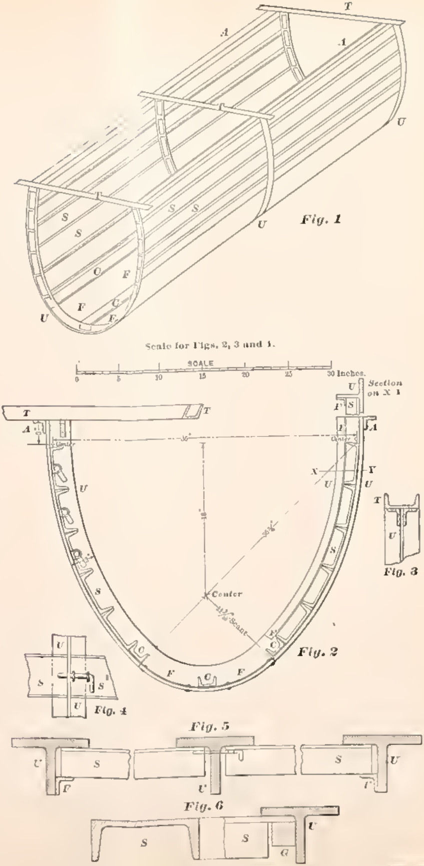
* These figures are kindly furnished by Colonel Waring.

HIRSH, SEWER TEMPLET



BOTTOM CONCRETE.

Cement,	18.5 bbls.
Sand,	2.7 cub. yds.
Broken stone,	15 "
Labor,	17 days.

BOTTOM LINING, TAMPED BEHIND IRON TEMPLETS.

Cement,	25.25 bbls.
Sand,	7.5 cub. yds.
Labor,	22 days.

SEWER TOP.

Cement,	26 bbls.
Sand,	3.9 cub. yds.
Broken stone,	13.6 "
Labor,	21 days.

For the sewer top, the center was first covered with a plastering not less than one inch thick, of mortar made of one part cement to two of sand. The concrete is placed on this, inside of wooden templets, before it sets, to a thickness of about six inches; and the key, between the templet frames which run on each side to within about nine inches of the center, is roughly plastered with coarse mortar.

With the new iron templet here described, no inside plastering seems necessary, except to fill the depressions left by the ribs. The cost of this is but trifling.

The lowest rate of wages at Middlesborough is $1.50 per day. All the work is done by men receiving this, except the tamping gang, who get $1.65, and the cement mixers, who get $1.75. At the prices for brick masonry paid in Middlesborough, the saving in cost is about 25 per cent. in favor of the concrete sewer as compared with brick, and Colonel Waring thinks the results with the cement sewer much the better.

But while a cement sewer might be particularly well adapted for this kind of clay soil, it is questionable whether the amount of leakage through an ordinary soil might not be a serious objection. The substitution of cement for brick, of course, materially facilitates the discharge through the sewer, the coefficients of roughness, by Kutter's formula, being 0.010 and 0.013 for neat cement and for brickwork respectively.

XXIII.

RAPID TRANSIT IN CITIES.*

By H. W. Spangler, Active Member of the Club.

Read May 16, 1891.

The pages of our Proceedings have numerous articles by members of the Club on the subject of rapid transit, and in our meetings and in the daily and technical papers the subject has been thoroughly gone over from almost every point of view. Without going into the advantages or disadvantages of the many schemes proposed, this introduction is for the purpose of setting forth what has actually been done in Philadelphia in this line.

The carrying of the main steam roads, the Pennsylvania and Reading roads, to the center of the city, added and will continue to add much to the transit facilities of people living in certain sections of the outlying portion of the city, but is not likely to add much to the rapidity of the great bulk of travel. The substitution of cable for horses has practically been for the convenience of the company, as it has added little to that of the public; and while it is promised that the cable speed will be increased at some future time, it is difficult to see how more than a small portion of the long-distance travel in the city can be greatly benefited thereby.

What was apparently the first practical step toward rapid transit was the approval on February 16, 1891, of the Market Street Elevated Ordinance. The following are the principal provisions of that ordinance:

The Department of Public Works is to prepare specifications

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* The Committee on Information and Entertainment decided, last spring, to try the plan of setting apart one meeting in each month for the consideration chiefly of some one subject, upon which subject the Committee should endeavor to procure papers and discussion. In pursuance of this plan, the meeting of May 16, 1891, was devoted to the question of Rapid Transit in Cities, and the result was the series of papers and discussion presented herewith.

In this connection it will be well also to refer to the paper on the Application of Electric Motors to Elevated Railways, by Mr. William H. Burr, in Vol. VIII, No. 1, of these Proceedings, dated January, 1891.

for an elevated railway, and the Mayor is to advertise for sale the permission to build a double-track elevated railway in the middle of Market Street from the Delaware River to Juniper Street; on Juniper Street to South Penn Square; on South Penn Square to Broad Street; on Broad Street to Market Street, and in the middle of Market Street to Sixty-third Street. The company securing the right to build must strengthen Market Street Bridge and keep it in repair. The contract with the city must be executed within thirty days after the acceptance of the bid.

The company must build the road throughout its entire length on iron or steel trestles, leaving eighteen feet clear headway between the under part of the trestle-work and the curb line of the street. Metal catch-pans are to be provided for the entire length of the structure. Authority is to be given for crossing streets and for the use of the streets.

The stations of the road are not to be farther than one-half mile apart, and no part of the road east of Forty-third Street is to be used for the storage of cars. No bituminous coal is to be used as fuel in locomotives, and the gauge is not to exceed 4 feet 8½ inches.

The plans and construction must be approved by the Department of Public Works; and the streets, pavements, etc., must be restored to their proper condition.

From 6 to 9 A.M. and from 4.30 to 7 P.M. cars must be run every five minutes, and from midnight to 5 A.M. every half hour, and at not greater than ten-minute intervals throughout the rest of the day.

The ordinance also fixes the rates of fare, the security for damages, the penalties for using the road for freight traffic, and the method of adjusting differences with connecting roads.

The company must begin to construct the road within six months, and complete the entire line in two years from the execution of the contract.

Before the contract is signed the schedule of bids must be submitted to Councils and their consent obtained.

The bids for this road are asked for by June 16.

A second ordinance, approved April 1, 1891, may result in portions of West Philadelphia obtaining more rapid transit than

at present; but as it is for the application of the trolley system to portions of the Traction Company's lines in West Philadelphia, it is not probable that the people in that section will be greatly benefited thereby.

The ordinance which is now (May 7) in Councils, for the construction of an elevated railway to Tacony, differs considerably from that of the Market Street line. The principal differences, exclusive of the financial one, are, that fourteen feet headway is required instead of eighteen, and that drip-pans are required only at crossings.

Five-cent fares apply from 6 to 8.30 A.M., and from 5.30 to 7.30 P.M., instead of from 5 to 9 A.M. and from 4 to 7.30 P.M. No provision is made for fare ever being less than ten cents throughout the rest of the day, while on the Market Street line, after two years, five cents only can be charged at all times.

In the proposed Northeastern Railway, no train at all need be run during the day, unless the company sees fit, as provision is only made for the running of trains at intervals of not more than one hour during the night.

And last, but greatest, the City of Philadelphia proposes to give away a valuable privilege for which a permanent income should be obtained.

In this connection, while it is believed that no system of surface traction can give the desired rapidity of transit for a large city, but that some underground or overhead system must be looked to, it may be interesting to note a few of the conclusions reached by the Census Bureau on the Relative Economy of Cable, Electric and Animal Motive Power for Street Railways as published in Bulletin No. 55, of the Census Office. This bulletin embraces statistics of fifty lines of street railways, ten of which are operated by cable, ten by electricity (nine of which are trolley and one storage battery) and thirty by animal power. The figures given for the electric roads are in some cases estimated for only portions of a year's work, and are probably higher as to operating expense and lower in all that relates to car-miles run and passengers carried than will be the case in a few years. The expenses of operating per car-mile for electric cars varies from 8.34 to 36.04 cents, for cable from 9.39 to 21.91 cents, and for animal power from 9.10 to 27.02 cents.

Omitting the single railway operated by accumulators the average cost of operating per car-mile is least in electric railways, being 13.21 cents. Then come the cable system at 14.12 cents, and animal power at 18.16 cents.

The operating expenses per passenger carried are least with the cable, being 3.22 cents. Animal power costs 3.67, and electric railways 3.82 cents.

As far as operating expenses per car-mile are concerned, both cable and electric railways have considerable advantages over those operated by horses; but the number of passengers carried one car-mile is least with electric railways, being 3.46, while cable cars carry 4.38 and horse roads 4.95 per car-mile, the explanation doubtless being that electric roads occupy lines over which the traffic has been only partly developed.

A comparison of the first cost and number of passengers carried, per mile of street occupied, shows that the cable railways under consideration were built at a cost over seven times as great as that of the electric railways; but the density of passenger traffic is about six times as great upon the cable as upon the electric railways.

If the fixed charges are added to the operating expenses, estimating them uniformly at six per cent. of the first cost, the order of expense is still the same per car-mile—viz., electric, cable, and horse roads—while the order per passengers carried is as follows: horse, cable, electric, instead of cable, horse, electric, as is the case when operating expenses alone are considered. The figures show also that if the car-mile is taken as the unit of traffic, the first cost relatively to the business done is in the following proportion:

Animal 1.00, electric 1.23, cable 1.91;

and if the number of passengers carried is taken as the unit of traffic:

Animal 1.00, electric 1.75, cable 2.15.

XXIV.

ELECTRIC RAILWAYS.

By G. Herbert Condict, Visitor.

Read May 16, 1891.

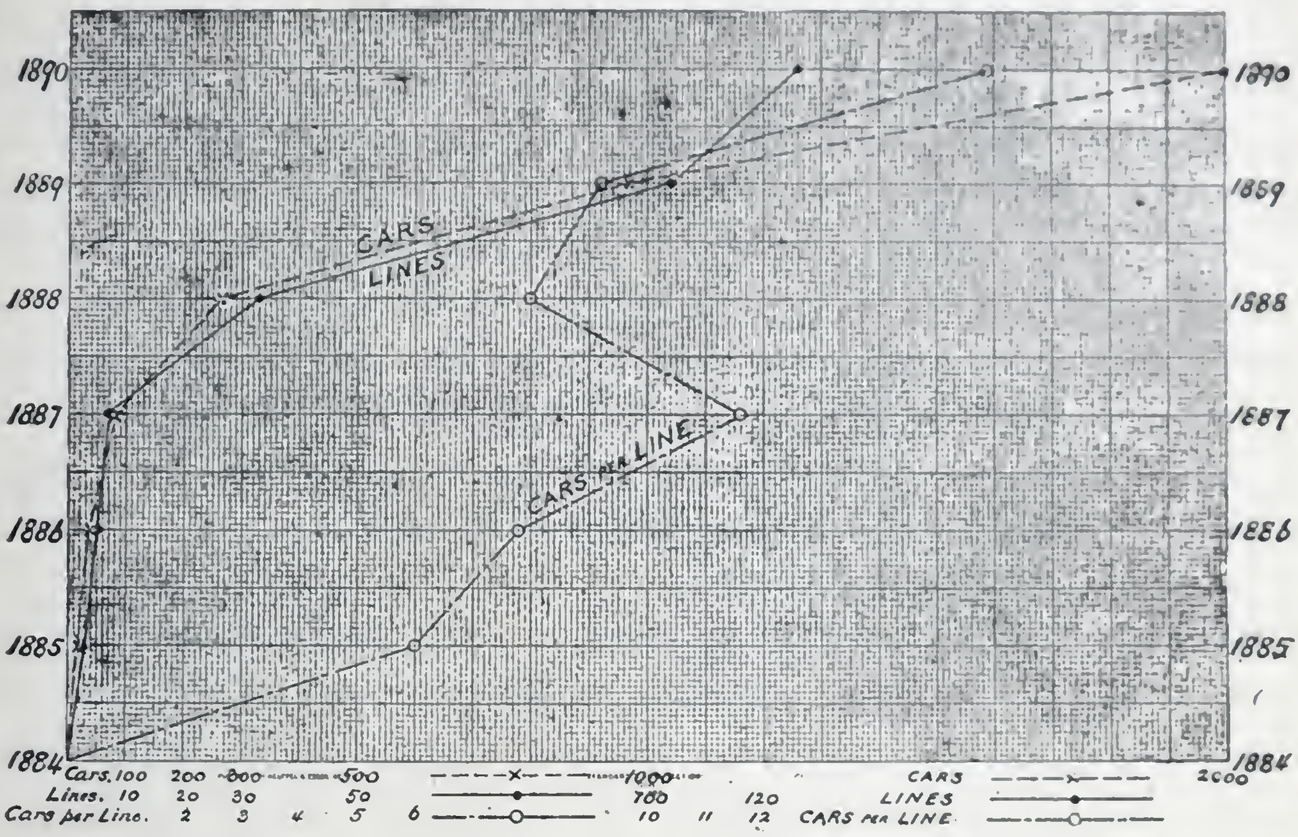
Although a few electric cars had been operated for experimental and exhibition purposes previous to 1885, it was not until that year that the first cars intended for actual everyday service commenced making regular trips.

That electric traction on street railways has made wonderful strides since that time is evidenced by the following, taken from the Census Bulletin (issued April 24, 1891) on "The Relative Economy of Cable, Electric and Animal Motive Power for Street Railways:"

"Electric motive power, upon which both popular and technical interest is at this time concentrated, has a history in this country of only about six years, and, notwithstanding its brilliant achievements, can as yet be in but an early stage of development. The fact that over one-fourth of the street railway companies in the United States are already operating wholly or in part by electricity only indicates how great is to be the importance of this, as yet, indeterminate factor."

What is this "history . . . of only about six years?" From *The Street Railway Journal* and *Electric Power* we gather a few figures. The number of electric railways put in operation in the United States and Canada each year for the last six years is as follows:

1885	3 roads	13 cars.
1886	5 "	39 "
1887	7 "	81 "
1888	33 "	265 "
1889	104 "	965 "
1890	126 "	over 2,000 "



GRAPHICAL REPRESENTATION OF THE ABOVE TABLE.

Mr. F. J. Sprague, of the well-known Sprague Electric Railway system, is the authority for the statement that "horse railroads, which have been in use for over fifty years, represent an investment of about \$58,000,000, and electric railways over \$50,000,000; while the cable roads, which have had a commercial existence four times that of the electric system, have less investment than electrical railways, or about \$49,000,000;" and that "there are now in operation, or under contract, . . . not less than 325 roads in the United States, England, Germany, Italy, Australia and Japan, requiring over 4,000 cars and 7,000 motors, with 2,600 miles of track, making a daily mileage of not less than 400,000 miles, and carrying three-quarters of a billion of passengers. Nearly a quarter of the entire street trackage in the United States is electric, about two-thirds horse, one-sixteenth dummy, and one-twentieth cable."

Shall we for a moment endeavor to become acquainted with a few of the reasons why there should be such a marvelous growth in such a short space of time?

Let us view the subject from each of the three different standpoints of the passenger, the property-holder and the stockholder, in order that our opinions may not be one-sided or partial.

First, as a passenger in a street-car, anxious to reach some point near or far, on business or pleasure, having the usual desire to get to the destination quickly, in safety and in comfort, and the fear, sometimes felt, that something will break down and cause an appeal to "shanks' mare." We can all join, without exception, in the view from this point; for who is there present in this company to-night who has not "been there," and who has not been often disappointed in his hope of a successful issue out of his anxieties? If it were not so the *question* of "rapid transit" would not be before you at this time.

First, let us consider speed.

The adaptability of electric traction to all conditions of service is most worthy of note. In the attainment of rapid transit the following conditions must be fulfilled: quick starting and stopping, and the maintenance of a high rate of speed for long or short periods. Quick starting and high speed require great power, and that the electric car motor has, almost to an unlimited extent; and, moreover, this power is absolutely under the control of the car-driver. Very low and very high speeds, with all intermediate degrees, are maintained with ease and smoothness. And thus, as far as speed is concerned, the electric system is adapted for use under all conditions, whether in streets, crowded or uncrowded, or out in the suburban districts where speed is limited only by the conditions of safety to the car itself and to its passengers.

Mr. H. M. Whitney, President of the West End Railway Company of Boston, in an address to the stockholders of that company, said: "The time from Arlington to Harvard Square, four miles, is twenty minutes, twelve miles per hour; the average rate of speed of elevated roads in New York is only 10.89 miles per hour. The West End electric cars are now making in the city of Cambridge a rate of speed absolutely one-eighth more than the elevated trains in New York."

Safety being the only limitation to the speed of electric rapid transit, let that be considered next.

Quick stopping and absolute control are elements in obtaining high average speed, but they are most important when considered as elements of safety. To the advantages of all the methods for

quick stopping now in use on other systems of street-car propulsion is added that of the reversibility of the electric motor. The fact that electric cars are easily controlled is evidenced by the small number of accidents which have occurred with them. This showing is remarkable when the high rate of speed allowed on some roads is taken into account.

In the next place, the electric current used on street railways is *not* dangerous to human life. The *Boston Daily Advertiser*, August 26, 1890, says: "The great objection to the use of the overhead wire has been the fear of serious injury to individuals. On this line of inquiry we have received full information, and find that of the sixty-nine cities from which responses have been received, reports of accidents are confined to fifteen. Of these only eight have resulted in serious or fatal injuries to human beings, the others being the killing of horses by falling wires, which all the companies admit is likely to occur. Of the human beings killed, in all but two cases the accident was due to other causes than the electric wire, and in both cases where the wire apparently brought death, they were by electric light wires. . . . We have not heard of a single death from the trolley wire. . . . In a great majority of cities no accidents whatever have happened, and where they have occurred the fault cannot be said to be due to the electricity from the overhead wire."

This question of safety not only concerns the passenger, but also everyone who may come near the road or cars.

Given speed and safety, the next wish of the passenger is for comfort.

In starting and in changing from one rate of speed to another the movement of an electric car is perfectly free from jerk and jar, a fact much appreciated by those who have involuntarily practiced gymnastics in a cable car.

The sympathetic passenger rejoices because there are no horses to strain their limbs and muscles in starting the car and in climbing hills, or to slip on pavements.

The dim, smoky, oil-smelling lamp, which simply "rendered the darkness visible" and gave to the oculist a great deal of his business, is replaced by the soft, bright, inodorous incandescent light.

One of the most emphatic and reasonable objections to the electric car has been that the noise from the gearing was very disagreeable, almost unbearable, not only to the passenger but to all who might come within hearing of the whirr and clash of the grinding teeth. In many cases this noise has been greatly reduced or done away with entirely, generally by reducing the number of gears or by inclosing them in an oil-tight box, and latterly by doing away with the gears entirely, the armature being placed directly on the axle of the car.

Being assured of speed, safety and comfort, the passenger naturally desires to have the consciousness that the system which is doing all these things for him is reliable.

Undoubtedly, in the early days of electric traction, as well as of every other system, break-downs were numerous, and delays resulting therefrom so exasperating to the average passenger that those not understanding the circumstances were loud in their denunciations of the whole system. But as experience was gained by the manufacturers, crude methods and mechanisms were superseded by those better fitted to perform the work required of them. It was almost entirely in the mechanical department that improvement was made, not particularly by the introduction of new appliances, but by the employment of improved designs and more substantial construction in those already in use. The result of all this improvement is that of all systems of street-car propulsion, the electric is rapidly becoming the most reliable. Even in the midst of the severest sleet and snow-storms the electric car moves triumphantly along.

And now the property-holder steps forth to be heard, as he has so often done of late in our City Councils. He can, of course, testify that as the road affects the passenger so it also affects him, for a great factor in determining the value of his property is the extent and popularity of the transportation facilities enjoyed between it and the outside world. Except as providing such facilities, a railroad of any kind is of no particular benefit to a property, and we will therefore consider the objections which the property-holder makes to the introduction of an electric railway. Noise and danger to life have already been alluded to. The chief objections to the overhead system are unsightly appearance and danger from fire.

That the wires, with their supporting poles, do not improve the appearance of any street cannot be denied, but their unsightliness has been so much exaggerated by the opponents of the overhead system that it would appear that they are having rather hard work in finding serious objection to its introduction.

As to the next objection: danger from fire.

The electric current needs to be controlled, as well as every other force in the universe. We take most extraordinary care to preserve our lives and property from the many destructive agents by which we are surrounded. We compel a man to use every precaution known to modern science when he introduces into his building fire for heating and cooking, gas for lighting, electricity for power or lighting. Cannot you likewise compel the electric railway man and his most able abettor in this trouble, the telephone and telegraph man, to provide protection against this new danger, which in a very few isolated instances has been brought to our attention because someone has been grossly careless or perilously economical?

The most approved system of guard-wires should be placed above the trolley wire. A weak or poorly insulated guard-wire should not be tolerated, as it is worse than useless.

House-top telegraph and telephone wires should be done away with, as through sagging or breaking they come in contact with the trolley wire and cause the trouble in the majority of cases.

Let us complete our hasty view of this subject by looking through the eyes of the stockholder, who, although governed to some extent by the wishes of the passenger and the property-holder, is anxious to introduce upon his road that system of motive power which will give him the greatest return for money invested. Viewed from this standpoint, the subject will have to be divided into three heads, each of the three systems (overhead, conduit and storage battery) being considered separately.

The Census Bulletin, already alluded to, makes the following comparison between the operating expenses of thirty horse roads, ten cable roads and nine overhead electric roads:

Average cost of operating per car mile: Horse, 18.16 cts.; cable, 14.12 cts.; electric, 13.21 cts.

Taking into account the fact that electric traction is still in its infancy, this showing is most favorable, and demonstrates

most clearly that the system can compete successfully with the older methods in regard to economy. The expense of fuel; attendance (exclusive of motor-men and conductors); oil and waste; repairs to power plant, motors and line; charges for interest, taxes and insurance; taken from the returns from fourteen different roads, give an average cost of 5.5 cents per car mile.

The underground conduit system of electric railways has all the advantages of the overhead system (speed, safety, comfort) without the disadvantages of the overhead wire. This fact will appeal particularly to the property-holder.

But the stockholder is still somewhat skeptical, and for good reason; for up to date the system has (for lack of proper construction) proved unsuccessful in commercial service. I say "from lack of proper construction," because there is no reason why this system should not be used if good substantial conduits were provided, such as are now used in the best cable railway operations, with adequate facilities for drainage. Some one, or the combination of two or more, of the many conduit schemes in which the supply conductors are almost completely insulated and the bare working conductors are divided into sections, will undoubtedly be brought to a successful issue when the countless switches, magnetic devices, etc., now employed in most of them shall be discarded or superseded by simple and reliable mechanisms. The question of first cost is a very prominent factor in the consideration of the underground conduit system. Underground work is expensive both in installation and maintenance. The cost of operating street-cars by this system will probably be about the same as by the overhead system.

Now, for a moment, let us consider the much-abused storage-battery. Until the weight shall be materially decreased and the power capable of being stored in a given space increased, this system of traction will be confined to roads on which the grades do not exceed six per cent. In the eyes of the passenger and of the property-holder, storage-battery traction combines all the advantages of every other system of street-car propulsion without any of the disadvantages. Speed, safety, comfort, each car absolutely independent of every other car, not affected by the temporary stoppage of the power plant, no overhead wires with their objectionable features.

But the investor who is about to lay out his money in a street railway hesitates as he views the past history of this system ; and although he has always expressed a desire to introduce it on his road, he has been constrained, except in a few instances, to employ one of the more or less objectionable systems, because the storage-battery has not been noted for its economy. The work has been performed easily and satisfactorily for a while, but in a comparatively short time disintegration has rendered the plates inefficient and finally useless. This item of deterioration and consequent expense has been the one hinderance to the victorious march of the storage-battery car. I say "victorious march," for those who understand the business best feel that the day is not far distant when the durability of the battery, and therefore the commercial economy of storage-battery traction, will be assured beyond all question.

Profiting by the experience of the past, defects have been met and overcome. The fact that the storage-battery-traction problem has been the most important and yet the most difficult to solve of all street railway problems is evident to all.

Most encouraging reports are coming in from various parts of the world in regard to the working of this system. In several places the cars are now performing their work most satisfactorily. Two or three street railway companies have decided to equip their entire roads with storage cars. In one of our large cities a road will soon be operating forty cars.

At this present time it is impossible to give any reliable figures as to cost of operation. Many estimates have been made, based on the probable life of the storage battery, as calculated from the performance of batteries used on a few cars, the majority of which were operated simply for experimental purposes. On a fairly level road, operating, say, twelve or fifteen cars, the cost would probably be about the same as horses—viz., about ten cents per car mile. Of course, as the number of cars operated on a given line is increased, the cost per car mile will be decreased. Some of the most enthusiastic advocates of the storage battery are rash enough to maintain that a road equipped with fifty cars or over can even now be operated at a less cost with storage batteries than with any other system.

XXV.

THE RELATION OF ELECTRICITY TO RAPID TRANSIT IN CITIES.

By T. Carpenter Smith, Active Member of the Club.

Read May 16, 1891.

In discussing the relation of electricity to rapid transit in cities, it is not so much my intention to give any detailed description of the methods now in use, but rather to lay down the general lines upon which any argument as to their advantages or disadvantages should be conducted. I also wish to restrict myself to the discussion of their use in the case of large cities only, more particularly our own. The conditions here are, to a certain extent, extreme ; the traffic within a certain district being extremely heavy, and beyond that quite light.

The conditions of a large city spread out over a great area, with a medium or light traffic in each part of it, would, of course, considerably modify the conclusions at which I may arrive in discussing the question as applied to Philadelphia.

As related to rapid transit, electricity is purely a method of transmitting power, and its chief advantage arises from its flexibility and from the fact that the losses incurred in its use are more easily calculated and more readily controlled than those of almost any other means of transmission.

From the large number of apparently successful installations of electric railroads we might suppose that the system is better than any other. But this appearance of success arises from various conditions which have never yet been fully considered ; and as I expect to show that the electric system so far has no particular advantages over many others which have been tried and pronounced failures heretofore, we must compare it with other systems now in use in large cities with reference to their respective advantages, disadvantages and limitations. To consider the last question first, we may divide traffic into the two broad classes, surface and non-surface, the latter including both underground by tunnels and overhead, or structures erected for the purpose.

For surface travel the ordinary methods in use are: stages running on the ordinary street surface; horse cars; cable cars, operated by means of conduits; steam cars; compressed air or other similar motors; electric cars, operated by means of the trolley or overhead system; and electric cars operated by means of storage batteries. All of these, except the first, run on rails set for the purpose on the surface used for general traffic.

Leaving out the stages on the ordinary street surface as having had their day, and as practically not entering into this question save as adjuncts to other methods, we may say that all the other systems (with the exception of horse cars, which are limited by the nature of the power used) are limited to a speed of from eight to ten miles an hour, without stops, where the traffic is crowded, and from ten to fifteen miles an hour in the outskirts of the city. This limitation does not come from inability to stop and start rapidly, nor does it come from any want of ability to apply sufficient power to the cars themselves, but simply and wholly from the fact that the safety of other traffic in the streets and cross-streets prohibits traveling at a greater rate of speed. We may therefore say that there is absolutely no solution to the question of rapid transit to be found in surface roads, by which I mean roads and thoroughfares which have to be used at the same time for general traffic.

We may also, for the same reason, leave out all consideration of questions relating to the "short haul." It is only with the long distances, say, of over a mile, that we are interested at present.

Let us now consider, in relation to this "long haul," the various methods now applied in surface travel. First, in their relation to the public; second, in their relation to the property-owner whose premises they pass; third, in their relation to their promoters and stockholders or owners. It must be noted that there are certain conditions which must be fulfilled in two of these relations. There are other conditions which need only be fulfilled in one of them.

Taking first the relation of the systems to the public, we may say that there are five general requirements which any system must fulfill in order to do its duty properly to the general public of the cities where it may be used.

First.—Ability to run continuously and successfully. This we may limit, for the purposes of discussion, to the question of the liability of the break-down of a part affecting the whole.

Second.—The ability of the system to take care of sudden increases in travel, whether by reason of the influx of large numbers of travelers, or of the increased traffic during certain hours of the day. This includes ability not only to carry a larger number of passengers, but also to carry those passengers in a proper manner.

Third.—Non-interference with the use of the streets by other vehicles or by foot-passengers, or for the purpose of the public weal, as in the laying of gas and water-pipes, sewers, etc.

Fourth.—Non-interference with public health; and

Fifth.—They must not introduce new dangers peculiar to the system itself.

There are, of course, many minor questions which, however, may perhaps be properly classified under one or other of the above heads.

As to their relation to the property-owners we may say that there is one general question—viz., as to their effect upon property to increase or decrease its value—and this again would have to be considered in the two cases: whether the property was used for business purposes, or whether it was used for residence.

In the relation of the systems to the stockholders we may say that there are three points to be considered—viz., the chance of a breakdown of a part affecting the whole; the ability to take care of sudden increase of traffic; and the cost of maintenance; this last covering first cost by means of an interest and depreciation account.

As to the first requirement, in relation to the public, we may say that under this head we divide the systems into two separate classes: first, those in which the power is generated at a central station and distributed to the various cars upon the lines, which cars have in themselves no reserve of power or means of propulsion except that taken up at each instant from the transmitting medium; and second, those in which the driving power is carried on the car itself, each car forming a unit independent of all other units upon the system.

The first class comprises all cable and all electric trolley or conduit systems. These are liable to have the interruption of a part throw out of action the whole. This does not mean that the entire system may break down, but that such a large section may break down as to disable several cars or a section, which would necessarily interrupt the business of the whole.

The second class comprises all motors operated by independent steam engines, motors operated by compressed air carried in tanks on the cars themselves, and electric systems operated by storage batteries. These are not liable to such interruptions as are the systems of the first class, since the break-down of any one unit disables that unit only. Also the next car following can take care of the disabled one, provided the accident involves only loss of power.

As to the second requirement—the ability to take care of sudden increase of travel—we may say that all mechanical systems have practically the same standing. There may be said to to be one exception to this—namely, that steam cars require some time for the getting up of steam, and consequently are not so immediately available for use as would be the cable, the electric, or the air-motor car. Besides, there will be a certain waste of fuel if extra cars are kept standing ready fired-up for use, and this would not be the case with the other systems.

In regard to the third requirement—non-interference with the use of streets—we may say that the cable systems introduced are open to grave objections. The open slot in the center of the track, generally occupying the crown of the street, or the part best fitted for general traffic, is a very serious detriment, especially from the fact that the conduits, as ordinarily laid, prevent the use on the rails of vehicles using only one horse, while the danger of broken wheels and lame horses is very great. It may be said that we do not very often hear of such cases, but we must bear in mind that the reason for this lies in the fact that the public are driven off from that part of the street by reason of the existence there of the conduit with its slot; and we are now discussing not so much a question of condition as a question of right.

The steam motor is open to certain objections, the chief of

which has been that the noise of the escaping steam has frightened horses and other animals. This we need hardly consider, since no system of steam cars for use upon streets can be considered modern, in which either steam or smoke is allowed to escape in such quantities or in such manner as to have this effect. Moreover, it has been found that this frightening of horses and other animals does not come so much from any noise of the cars themselves, or from the discharge of steam or smoke, as from the fact that they are large moving bodies without horses in front of them. The same terrifying effect is observed upon all other mechanical systems, and it is only a question of a short time when animals in the street become accustomed to the new conditions. To the air-motor cars there is no objection which does not apply equally to all the others.

The overhead trolley system introduces the very decidedly objectionable feature of the fixtures required to sustain the wires; and the electric conduit system is open to much the same objections as the cable system.

The electric storage-battery system, like the air system, has no objectionable features which are not found equally in all the others. With reference to interference with the use of the streets below the surface, the cable is the worst, though this objection is really not so serious as to militate against its general introduction were it the only one.

With regard to the fourth requirement—non-interference with public health—we may say that the cable is the greatest offender, owing to the impossibility of keeping the conduits clean, and to their becoming a receptacle for the filth and dirt which should pass off by the sewers, but which instead is washed into the conduit from the surface of the street and there remains, a constant menace to the health of the community, especially in summer.

It is true that the adoption of the cable system, in itself, at once gets rid of a large amount of the dirt which would otherwise encumber the streets; but this applies equally to all mechanical systems, and must not, therefore, be placed to the credit of the cable system in comparing it with the others.

As to the fifth requirement—not to introduce new dangers peculiar to the system itself—we may say that the cable occupies

a medium position. We do not consider the danger which comes from the simple increase in speed and consequent danger to foot-passengers who may be crossing or using the streets, since that is common to all systems. But the fact that the cable system requires the use of the slot in the streets gives one more chance for injury to horses and to individuals, while occasionally a cable car gets absolutely beyond control owing to the "seizing" of the grip, which danger does not apply to any of the other systems, since in them the power driving the car is limited by that of the motor located on that individual car, while in the cable system the power is limited only by the strength of the cable, of the grip, or of the machinery at the generating station. This last may be, and, in fact, generally is, sufficient to overcome any braking power which can be put upon the car itself.

The trolley system also introduces a number of new dangers peculiar to the system itself, chiefly as to fire from the falling of other wires upon the trolley wire, which must necessarily be bare. The trolley wire is subject also to the wear and tear of the trolleys upon it, and to deterioration by reason of the burning caused by small arcs forming between the trolley and the wire. The danger arising from the multiplication of poles and wires is also great, but they are chiefly objectionable rather as unnecessary obstructions than from any immediate danger of injury to life.

The ever-present danger from fire, however, arising from the falling of other wires across the bare trolley wire must be carefully considered. The advocates of the overhead trolley system are very fond of claiming that if the other wires were kept in proper condition this danger could not arise, and that as long as other wires are permitted to be overhead, so also might their wires be. Two wrongs, however, do not make a right, and so far the other overhead wires have the advantage since they can be easily insulated and made fairly safe, while the bare trolley wire must always remain a source of danger. Not only this, but the fact that it is in itself a danger, should forbid its being allowed at all unless it can be shown that it is a very great public benefit, which so far has not been fully proved.

In their relation to the property-owners, we may say that the

cable cars probably do not introduce any damage or interference when the property is used for business purposes, other than that of preventing the free use of the streets for other vehicles, and the effect which they would naturally have to deteriorate the value of property owing to the unhealthy conditions which they introduce.

The electric overhead or trolley system is open to these same objections, with the additional one that the poles and wires are a constant source of obstruction; while the electric conduit would have much the same drawbacks as the cable conduit. All other advantages or disadvantages would probably be equally shared by any other mechanical system.

With regard to property used for residence purposes, we may say that both the cable and the overhead trolley systems have very serious disadvantages. The operation of both these systems causes a continuous noise, most perceptible and annoying at night, not only at the time of the passage of a car, but in the case of the cable by the continuous running of the same, and in the case of the trolley system, by the loud ringing noise of the trolley on the wires, which is heard for some time before and after the passage of a car.

In the residence portion of the city, also, there is always a greater proportion of women and children using the streets than is the case in the business portion of the city, and this requires that extra precautions should be taken to insure safety. We all are willing to endure discomfort and danger in our places of business for certain hours of the day, if by so doing we can earn the comfort and safety of those we leave at home, and secure peace and quietness for ourselves when we take our ease at evening time. The cable car, with its open slot, and the trolley, with its bare overhead wire, are therefore particularly objectionable in residence districts.

The steam car, the air motor and the electric storage car have no objectionable features not common to any system involving the use of cars traveling at high speed, and their operation does not interfere in any way with the use of the streets for other purposes.

In the relation of the systems to the stockholders we may that

the only new consideration, that of cost of maintenance, requires most careful study. Under this head must, of course, be included a fair percentage upon the money invested, and a reasonable allowance for depreciation. The latter can be made in the form of an annual charge for repairs, or can be put in the form of a sinking fund, to replace apparatus as it may wear out.

I have not considered the interest which the public has in the cost of maintenance, since we may take it for granted that no company will ever adopt a system which is so expensive to operate as to require the charging of an excessive fare. It has been proved that almost any mechanical system can be operated more cheaply than horse cars; and if the lines operated by means of horses can pay dividends on their present fares, so then can almost any mechanical system.

I shall not discuss the question of cost of maintenance, as that is a matter which must be studied and worked out by engineers. So far, the greater part of the information which we have on this subject comes from the experts of the various companies, who are chiefly interested in proving that their system costs anywhere from 15 to 150 per cent. less to operate than any other, generally without in the least knowing what the others cost. Similarly, many of those who are in charge of railroads which have been changed from horse-power to mechanical systems, while very good business men, are not practical engineers or accustomed to the cheap production of power.

To arrive clearly at the cost of running a plant of this kind, it would be necessary to have the records kept by some such competent man as we find in the large mills in New England, who can tell to a cent what every part of the process costs, and exactly what proportion each item of expense bears to the whole.

In concluding my consideration of surface railroads, I may say that apparently both the cable and electric trolley systems are open to grave objections against their extensive introduction. The steam-driven, the air-motor and the electric-storage cars do not seem to introduce any new difficulties. Yet these apparently have not been successful, and the cable and electric trolley systems have.

The reasons for this are many and various. In the first place,

it must be remembered that there has never been spent upon the steam, air or electric storage systems one-hundredth of the money which has been spent in developing the cable or electric trolley systems.

When steam cars were first discussed and introduced, the age was not ready for them; and the first crude attempts, instead of being encouraged, were hooted at and driven out of existence—the same with the compressed air systems. As time went on and the need of some other apparatus to take the place of the antiquated horse cars was more and more felt, the public looked eagerly for anything which promised to fill this want. Any suggestion of steam or air was met by the recollection, not of what the actual objections to them were, but of what the public feeling at a former time had been. No account was taken of the changed condition of public sentiment, but something new which seemed to promise better results was seized upon and eagerly accepted. In addition to this, the mystery which all electrical phenomena possess, seems to exercise a peculiar fascination upon the uninitiated mind. This feeling, which finds its expression in the oft-repeated sentiment as to electricity being the "most wonderful force of nature" and "only in its infancy," has done more injury than can well be imagined, as witness the many lamentable failures of electric lighting and power systems.

It must not be forgotten that the electricity in commercial use is not a "power of nature," but is simply, for all practical purposes, a condition of matter produced by well-known means and following well-known laws. We cannot get something for nothing, and the introduction of a generator, a transmitting wire and a motor is simply another double conversion introduced between the boiler and the finished product; while the percentage of loss so introduced is greater than the difference in economy between a well-constructed stationary steam engine and a well-constructed locomotive of similar type.

With regard to rapid transit by means of underground or overhead structures, we may say that it is in the underground structures that electricity by the trolley system seems to find its especial field. The absence of all deleterious gases renders it peculiarly suitable for this location, and the success or failure of

the large underground road in London operating on this system will be watched with great interest.

For overhead or elevated structures, while electricity is a very convenient and (as far as the public is concerned) an entirely satisfactory means of power transmission, it is questionable whether either the trolley or the storage-battery method will pay in comparison with steam locomotives.

On surface roads, running at from 8 to 10 miles an hour, the power exerted by the motor is greatest at the instant of starting the cars, and falls at once to a very small amount when they have once got into full speed; whereas, with heavy trains, traveling at high speeds, the greatest power is developed when doing the greatest amount of work, and this occurs after the train is speeded up.

Most persons, in discussing the use of electricity for ordinary railroads, talk as if the ordinary car, with a 30 or 40 horse-power motor, would be suitable, and consider only this quantity of power to be transmitted; whereas, in actual practice, locomotives on these trains will develop anywhere from 500 to 900 horse-power.

I think there are at present very few thoroughly practical electrical engineers who would care to advise the construction of an electric system between this city and New York with any idea of handling the present traffic between those two cities at anything like the present cost.

DOCUMENTS SUBMITTED.

The Secretary exhibited, for Mr. Samuel L. Smedley:

(*A.*) The Specifications and Proposal for an elevated railway on Market Street, Philadelphia, described in the paper of Mr. H. W. Spangler.

(*B.*) A plan and profile of Market Street, embracing its entire length, from the eastern boundary of the city at the Delaware River to the western boundary at Sixty-third Street and Cobb's Creek.

(*C.*) Two photographs of one and the same neighborhood (looking north from Eighty-ninth Street), on the line of the Ninth Avenue Elevated Railroad in New York City; one taken in 1879, or immediately after the building of the road; the other taken in 1889, or ten years later.

These photographs, which are reproduced in the frontispiece of this number,* show a striking change in the character of the neighborhood during the ten years immediately following the building of the elevated road. The first view shows only vacant lots, with here and there a rude shanty, on both sides of the avenue; while in the second the avenue appears lined on both sides with handsome business structures.

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* For the use of this plate we are indebted to the courtesy of the Phœnix Bridge Co., the constructors of the elevated railroad.

DISCUSSION.

By Pedro G. Salom, Active Member of the Club.

I desire to call the Club's attention to the present status of Storage Battery Traction as a factor in the Rapid Transit problem.

We are constantly met with the argument, in our endeavors to introduce storage battery traction, that the storage system is not commercially practicable; that the batteries are so expensive as to make the cost of such a system far greater than that of horse traction, but that some magician or inventor will come along some day with a new storage battery that will have no defects and that will last forever.

I need hardly say to the members of this Club, most of whom are engineers, that such ideas are crude and illusive. In the first place, the modern storage battery depends on the discovery of a principle, and there is no more hope of discovering a new battery than there is of discovering a new locomotive. It is undoubtedly true that improvements have been and will be made in the methods of construction, whereby the cost of manufacture will be decreased and the length of life of the battery increased—but this is true of any engineering problem. Such reasoners, therefore, can only be reached by the knowledge that a system is in successful commercial operation, or, in other words, is making money.

In the meantime, however, before this much-to-be-desired consummation is effected, we, as engineers, can study the problem from our vantage ground of knowledge, and administer a just rebuke to that class of alleged practical men who are always so eager to condemn methods before a fair trial has been made, and so anxious to "catch on" after a success.

It is now generally admitted by even the most learned and experienced horse-car managers that the overhead system of electric traction is a commercial success, and that it is cheaper than horse-power, although I received a letter a short time ago from one of these traction Solons, saying "*that horses* IS *a reliable power* and our company would not be disposed to make a change without full guarantee," etc.

Mr. Whitney, of the West End Road in Boston, has published

tables for the months of May and June of this year, showing the comparative cost of operating the two systems, and, notwithstanding the fact that the electrical system is so new and is operated under so many difficulties in such a crowded and busy city as Boston, and in spite of the further fact that the number of horse-cars operated was double that of the electrical cars, thereby making fixed charges greater for the electrical cars, the cost of operating the latter was approximately four cents per car-mile less than horse-cars, or about twenty-one cents per car-mile for electric traction and twenty-five cents per car-mile for horse traction, to say nothing of the largely increased earnings of the electric over the horse-cars. Now, the point I desire to make is this: granting that the storage system and the overhead system are practically identical up to the point where the motors on the cars receive the current (which I think everyone will admit), then, if it can be shown that the additional cost of battery renewal does not exceed four cents per car-mile, the storage system is at least as cheap as horse-power.

Each standard 16-foot car requires, in order to run constantly, 2 sets of 108 accumulators, or 216 in all.

216 elements at $6.00, ...	$1,296 00

As only the positive half of the elements requires to be renewed, and each positive half element costs $2.50, we would have,

216 x $2.50 = ...	$540 00
Deduct weight of old material, 216 x 10 lbs., 2,160 lbs., @ 3c. per lb. = . .	64 80
	$475 20

If the two sets of battery, therefore, will run a car 10,000 miles, or 100 miles per day for 100 days, it is manifest that the cost per car-mile would be 4.75 cents.

I will only add that the company I represent has, under the most unfavorable conditions, exceeded this record of 10,000 miles with two sets of accumulators, and is prepared to guarantee that the cost per car-mile for battery renewals on ordinary roads shall not exceed four cents, or is prepared to insure its batteries at this rate.

By Henry B. Seaman, Active Member of the Club.

The question of introducing electricity as a motive power for rapid transit lines depends, not so much upon the special advantages of any one system of electric propulsion over another, as it does upon the relative economy as compared with the existing use of steam. The fact that it is necessary to first generate electricity by the use of steam-power, with a consequent loss of 20 per cent., is a serious disadvantage of the new system; but, on the other hand, since the frequent stops necessitate the use of high-pressure engines, any power which can take advantage of the economy of expansion engines will derive corresponding benefits.

The greatest gain to be expected from the use of electric power, however, is the elimination of the smoke, gas and noises of the locomotive. The economy due to this item arises, of course, from the avoidance of damages to adjacent property, which form the most serious obstacle to the construction of elevated roads.

Property-owners who have actually benefited by the elevated roads, but whose benefits are not in proportion to those enjoyed by others more favorably located, consider the difference of increase of values of property as an indication of direct damage to themselves. Popular prejudice against successful corporations makes this condition the most serious menace to elevated roads, and any system of compensation for damages which does not consider the increased taxable values to the city will be a source of constant danger to any construction. The value of all property along the road should be appraised before construction is begun, and all damages thereto should be paid by the city within two years of the first operation of the road. In compensation for this the city should receive an interest in the earnings of the road. Such an arrangement would be particularly applicable in Philadelphia, where the common interests are large.

Another difficulty in the way of the introduction of elevated roads—and one from which Philadelphia would not be the first to suffer—is the zeal of the city guardians in protecting what seems to them to be the best interests of the people. In doing so they are apt to forget that in many cases the interests of the people and those of the road are identical rather than antagonistic.

Communities where elevated roads are being introduced for the first time often seek to lessen the objections to them by placing the structure high in the air, forgetting the fact that to raise the structure is to decrease its usefulness, without which there is no necessity for its existence. Where a minimum clearance is prescribed, this does not constitute the uniform elevation of the road above the streets, but only its elevation at a few exceptional points, while at other places the clearance must be considerably in excess of this. In establishing the grades of an elevated road, we first find the summits, and then, between these, run as economical grades as a proper consideration of the economy of construction and operation of the road, and the convenience of the traveling public, will permit. The surface of the streets between these summits recedes from the elevated structure, and the head-room at all intermediate points is increased. The only exception to this is where the grade of the road is parallel to the grade of the street, in which case a special clearance may be provided. To place the elevated roads so high as to detract from their usefulness is obviously as great an injury to the traveling public as to the road. The minimum head-room required by the roads more recently constructed in Brooklyn, N. Y., is twelve feet at the summits, but where the elevated structure is parallel to the surface of the street, fourteen feet is used.

The superstructure of an elevated railroad should be wholly of wrought iron—cast iron and steel being particularly objectionable in short spans, subjected, as these are, to constant vibrations.

The preliminary plans of any road must look to the eventual increase of traffic, and, where necessary, the details should be modified with this end in view. The loads which the structure must carry depend upon the speed to be maintained and upon the grades to be overcome. In the proportioning of parts the more recent practice in structural work allows different strains for live and for dead loads, with proper provisions for impact and for sliding friction. The foundations of masonry must be of sufficient depth and mass to give stability to the columns anchored to them; and in case they are placed along the curb line, special designs are often necessary in order to avoid encroaching upon private property. Drip-pans should be provided at all stations, over all cross-

ings, and wherever else they may be necessary to protect pedestrians from the drip of passing trains; but experience has shown that it is unnecessary that they should extend under the entire structure.

By John C. Trautwine, Jr.*

While the pair of photographs of the Ninth Avenue Elevated Railroad in New York, exhibited by Mr. Smedley, afford a most striking and interesting example of the relation between rapid transit extension and the development of real estate, and while they demonstrate beyond question that the building of a line of elevated railroad is not necessarily fatal to the growth of a handsome business neighborhood upon vacant lots, yet it would be hasty to assume from them that the erection of an elevated railroad along a given thoroughfare is in all cases the surest means to the development of property and to the enhancement of values along that thoroughfare.

To judge properly of the merits of this question, and to avoid being misled by a "before-and-after" contrast like the one here presented, we ought to be able to see, at least with the mind's eye, certain other photographs.

One of these would be a view showing what *would have been* the extent and character of the development of this neighborhood had no rapid-transit line been built. Very probably this development would have been less striking than that indicated by the present photographs; but, great or small, it must be deducted from the apparent growth, and only the balance placed to the credit of the elevated road.

Next we ought to see a photograph showing how this same neighborhood would have looked in 1889, if in 1879 rapid transit had been applied along this same line, but *in some other form* than that of an elevated road. Practically, the only other possible form is that of an underground road; and, if it could be shown (as from the records of the London underground railways, for instance) that such roads are more favorable to the development of property than are elevated roads, we must decide that the elevated road, by driving its underground competitor from the field, is injurious and not beneficial to real-estate interests along the line.

* Subsequently contributed.

Finally, we should see not only photographs, but also statistical tables or diagrams, setting forth the effect of an elevated road upon all the *other* streets through which it passes. The photographs before us show that within ten years of the completion of the road, handsome business blocks had sprung up in an up-town neighborhood of vacant building lots, but they throw no light upon the question of the effect of an elevated railroad upon down-town business streets or mid-way residence quarters.

To the student of social science this entire question of the effect of public improvements upon private interests affords occasion for a most interesting study of the relation between the community and the individual, and sheds a curious light upon the time-honored notion that honest merit is the sure and the only road to wealth. The man whose property, acquired, it may be, half a century ago, happens, through no merit, perhaps even through no shrewdness, of his own, to be advantageously situated as to the line selected by the company's engineers for reasons which he could by no possibility foresee, finds himself suddenly in possession of a fortune; while another, equally industrious, sober and honest, whose place is too near to, or too far from, the line, is as unceremoniously beggared.

Our system of compensation for damages does, indeed, in some cases, bring into play the paternal arm of the State, to interfere tardily and uncertainly in behalf of the individual; but the enormous growth of corporate power in our own times seems to threaten the permanence of even this partial relief, and gives color to the visions of those who look forward to an awakening of that giant corporation, "the parliament of man, the federation of the world," which shall absorb into itself alike the minor corporation and the individual, and dispense, monotonously perhaps, but equitably, its favors to all.

XXVI.

A PORTABLE PHOTOMETER FOR MEASURING STREET LIGHTS AND ILLUMINATION IN GENERAL.

By Carl Hering, Active Member of the Club.

Read January 17, 1891.

Some time ago the writer was called upon by a committee of councilmen from a town in this State, to settle a dispute regarding the candle-power of the electric street-lights, for which the town had contracted with a local electric light company. The company had contracted to furnish a certain number of incandescent street-lamps of 25 candle-power; but, after a year's trial, the town authorities thought that the electric lights at 25 candles were not as bright as the gas lights at 12 candles, and they concluded that they were not getting what they paid for. The matter was referred to the writer, to measure the actual candle-power of the lamps throughout the town, and make a report on their candle-power.

The electric light company suggested that the lamps be taken from the poles, brought to the electric light station, and measured there by means of the ordinary photometer. Although this simple method appeared satisfactory to the councilmen, it was not so to the writer, for obvious reasons which any electrical engineer would appreciate. It was concluded that the only satisfactory way was to measure them while on the poles, on different days, at different times of the evening, and without the knowledge of the company as to the days or hours when they were to be measured.

This required the construction of a portable photometer, which had to work equally well in all kinds of wind and weather. It had to be light and small, so as not to attract attention, in order that the electric light company should not know that the lights were being measured, and take unfair advantage of the opportunity to run up the lights. It was furthermore necessary that the results should be quite reliable, as the matter might have to go before the courts.

The conditions were, therefore, very difficult to comply with.

One of the chief difficulties was to get a standard light which could be used out of doors in a portable photometer. To use a standard candle was out of the question; its light varies with the temperature; it often requires trimming, and it would be almost, if not quite, impossible to prevent the wind from affecting its candle-power; for it is well known that even a person moving around in a photometer-room will make sufficient disturbance of the air to change the candle-power of a standard candle. Besides, a standard candle at its best is a very poor standard. For this and other reasons it was decided to try to use the Hefner-Alteneck amyl-acetate lamp. This lamp, as is well known, burns a liquid which is constant in its composition—that is, it does not contain varying quantities of more or less highly combustible materials, as benzines and coal oils do. All the dimensions of the lamp may be duplicated with great precision, thus enabling the whole standard to be duplicated with greater precision than a standard candle. If the flame is kept at a certain fixed height, by means of a gauge and a wick-screw, the light will remain constant. The original proportions were determined by its inventor by very exhaustive experiments made under the most favorable conditions with the standard candle, so that this lamp may be taken as representing a very fair mean of the average values of standard candles.

In constructing the photometer it was at first attempted to use this standard lamp in the portable photometer itself. It was suspended on a pivot, so that it remained vertical when the photometer was inclined, the axis of the pivot passing through the center of illumination of the flame. The lamp was inclosed by concentric, cylindrical tubes, with openings at the top and bottom, so that the wind, from any side, would not affect the draught or the flame. Lights were so arranged that the height of the flame could be adjusted without opening the inclosing case. But, notwithstanding all the precautions taken, it was found that the flame burned differently when in the wind-protecting box; and this lamp was therefore discarded as unreliable when used out of doors.

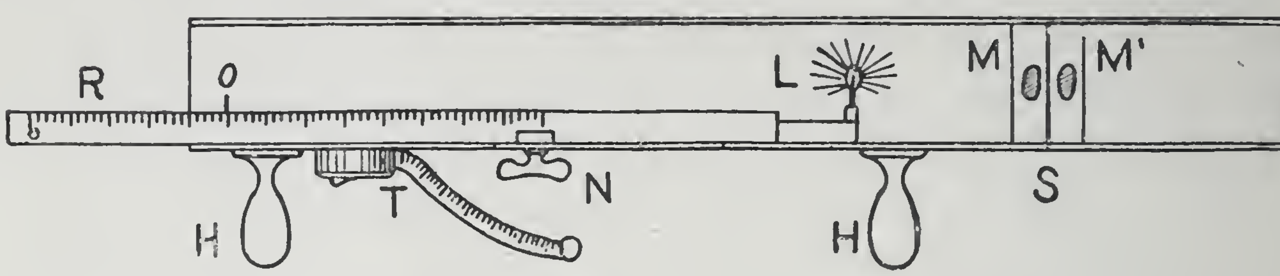
The next device tried was to take a portable outdoor lamp, such as is used by night-watchmen, having a broad, flat flame,

and place on one side of it a black screen, with a hole in it just opposite to the whitest part of the flame. As this part of the flame may be taken as remaining constant for all slight changes in the height, size or flickering of the flame, the light passing through this fixed aperture may be taken as constant and steady. The oil used was amyl-acetate, the same as in the standard above mentioned. This was found to work well in a room and when the photometer was held horizontally, but when used out of doors, or when tilted slightly, it was found that the glass or mica, shielding the flame from the draught, became turbid or blackened, making a very great change in the amount of light transmitted through it. It was noticed also that the flame, like that of a standard candle, appeared to get smaller and less bright in the cold air. It was, therefore, also abandoned.

There seemed to be nothing left but to use an electric light supplied by a portable accumulator. This was tried and was found to be perfectly satisfactory. The lamp used was a small four-volt incandescent lamp of about one candle-power, requiring a current of slightly less than an ampere. The accumulators consisted of two cells placed in a wooden box having a shoulder-strap, enabling it to be carried by the operator at his side. The weight of it complete was about twenty pounds. The cells were sealed with lids before the acid was added, and the whole was covered with a thick layer of powdered carbonate of soda, so that if any acid did come out through the vent tubes, it would be decomposed and then evaporate.

As the voltage of an accumulator will become less and less as it is being discharged, it would change the candle-power of the light very materially. To get over this, the accumulators were chosen of such a capacity that the amount of current used in one set of tests was only about one-fiftieth of its capacity; the fall in potential for such a small discharge may be taken as negligible. Furthermore, as the light was turned on for only about half a minute at a time, with intervals of rest of five or ten minutes, the cells had time to recuperate. The cells were discharged slightly before the test, in order to bring them down to their normal and constant voltage. Comparisons of this light with a standard during different parts of the evening, showed it to be quite reliable and constant.

The photometer itself consisted of a light wooden tube of square cross-section, 4 inches to a side, about 3 feet long and open at both ends. The adjoining figure shows a view of it with one side removed to show the inside. The usual screen *S*, with a grease



spot, and mirrors *M M'*, was placed near the right-hand end, and a square opening left in the side of the tube opposite to it to look through. The tube was blackened inside and outside with a paint made by mixing much lampblack with a little very dilute shellac; this paint, in drying, leaves no gloss. It was supported by two projecting handles, *H H*, the right-hand one being nearly under the center of gravity, so that the whole could readily be supported by the right hand alone. The small electric lamp *L* was secured to a block capable of being slid along inside of the tube by means of a projecting rod *R*, having a scale attached (as shown), which indicated the distance of the lamp *L* from the screen *S*. This rod, with the lamp, could be securely clamped at any desired distance from the screen by a thumb nut *N*. A 15-feet tape in a spring case *T*, without pawl and ratchet, was attached on the bottom near the left handle. A small switch (not shown) for turning the electric light on and off was also secured near the left handle.

To use the photometer it must first be standardized. This is done in any convenient room which can be darkened. The instrument is laid on a table with the standard Hefner-Alteneck lamp above mentioned, which is placed at a fixed and known distance opposite the right-hand end of the photometer tube. The small electric light is then turned on, and moved forward or back, until the grease spot seen in the mirror *M'* on the *right-hand* side of the screen *S* disappears altogether. The left-hand side (toward the small electric light) was not considered at all. This adjustment, therefore, admits of considerable precision, as there is no difficulty in making the grease spot disappear on

either one side or the other; the difficulty is in making it nearly disappear to the same extent on *both* sides, and it is here that the large personal error enters in ordinary photometric work, in which no two operators will set it alike. After making this adjustment the electric lamp is firmly secured in that position, and the photometer is ready for use.

To use it in measuring street-lamps, or any other source of light, the right-hand end is pointed toward the light in either a horizontal, a vertical or an inclined direction; the small electric light is then turned on, and the whole tube moved toward or away from the light to be measured until the spot of light again disappears on the mirror M' to the *right* of the screen S. By measuring the distance between the screen and the light to be measured, and knowing the calibrated value, the candle-power of the light is readily calculated from the well-known laws. The distance from the screen to the large light is measured by means of the spring tape T, which passes directly under the screen, and may be easily read by the operator. The small switch placed near the left-hand handle (not shown in the figure) enables the current for the small lamp to be turned on and off readily, so as not to burn it longer than just enough for the test.

It will be noticed that in this photometer only the mirror on one side of the screen S need be observed, not both, as is usual. The grease spot may therefore be made to disappear entirely, which admits of an adjustment more accurate and decided than the usual method. It is for this reason that this photometer is even more accurate than the usual one in which the balance is produced on both sides of the screen. The candle-power of the small light, as well as its distance from the screen, need not be known or measured; they must merely remain constant. This light merely serves as a constant secondary standard of light which will at all times reproduce the same illumination of the screen as that produced and balanced by the real standard during the calibration. In other words, it forms an adjustable and portable unit of *illumination* of the screen as distinguished from a unit of *light*.

It is evident that this unit of illumination should be so chosen

as to suit the light to be measured, otherwise the tape required to measure the distance might have to be impracticably long; and this should be taken into consideration in choosing the distance to the standard lamp in calibrating the photometer. For measuring very bright lights the standard should evidently be brought near to the screen *S*, so as to make the unit of illumination greater. In the measurements above mentioned, the lights to be measured were from 10 to 25 candle-power, and it was thought that from 4 to 6 feet of tape was a convenient distance, being an average of about $1\frac{1}{2}$ inches per candle. This would require, as a unit of illumination of the screen, a little less than one foot-candle. For convenience in making calculations the standard was placed at $14\frac{1}{8}$ inches ($= \sqrt{200}$) from the screen in the calibration. This gave such a unit that the square of the distances in tens of inches is double the candle-power of the light to be measured, a calculation which is readily made mentally, approximately at least. A difference of one candle-power in the unknown light would therefore require a movement of the photometer of about $1\frac{1}{2}$ inches; a fraction of a candle may therefore readily be detected; hence the photometer was quite sensitive for this class of work. The end of the tape was held up to the center of the lamp by an assistant with the aid of a pole. The spring-case of the tape kept it stretched so that the tape was virtually a fixed rule or scale over which the whole photometer was moved. The right-hand end of the tube must be long enough to shield the screen from the light of other light or of the moon.

This form of photometer has the further advantage that it can be used to measure "illumination" as distinguished from the candle-power of a light. For instance, the illumination on a desk, for reading or writing, the diffused illumination in a room, the light from a north window, or from a chandelier, daylight in general, moonlight on the streets, sunlight, etc., cannot be expressed in candle-powers; they must be measured in units of *illumination*, the unit being the illumination produced on a surface placed at a distance of one foot from a standard candle. In measuring such illuminations, the distance from the screen of the photometer to the source—as, for instance, in the case of daylight—is, from its nature, an immeasurable quantity.

To use this photometer for such measurements, the right-hand end of the tube is made in such a way that it can be taken off, so that the grease-spot screen forms the end of the tube. The photometer is calibrated, as before, but instead of securing the rod containing the little lamp, its position should be read on the scale shown in the figure, the zero of this scale being such that the reading gives the distance of the small light from the screen. Being thus calibrated, it is ready for use. To use it, as, for instance, to measure the illumination on a desk produced by daylight, the photometer is placed vertically, so that the screen is on a level with the desk, and the electric light is moved in its position until the grease spot disappears. From the reading of this position, and that of the calibration, the illumination in foot-candles is readily calculated. From this the number and position of electric or gas lights, necessary to reproduce such an illumination, may then readily be calculated.

For measuring daylight the auxiliary electric light used must be very much brighter than before, at least 16 candles, and preferably more. As the electric light is very yellow compared to daylight, it is not so easy to make the grease spot disappear entirely; but this is no serious objection, as great accuracy is not necessary in such measurements.

XXVII.

AN ACCOUNT OF A PHOTOGRAPHIC SURVEY.

By Charles H. Haupt, Active Member of the Club.

Read February 4, 1891.

The principles and methods of photographic surveying have been fully and clearly set forth in such works as those of Laussedat and Ducrot,* of the French Engineer Corps, and Lieut. H. A. Reed, U. S. A.† The object of the present paper is to describe a survey in which these principles and methods were applied to a study of a portion of the Schuylkill River and Fairmount Park in the vicinity of the Fairmount dam and water works.

A base-line AB, 947,336 feet long, was measured off upon the west or right bank of the river opposite Lemon Hill, between station A, upon the bluff overlooking the western end of the great curve of the Pennsylvania Railroad, and station B at the north end of the new bridge which carries Thirty-fourth Street over that railroad. The bearing of this line (N. 49° 40′ W.) was determined by means of a compass laid upon the camera box, and its length was measured by triangulation.

It may be well to enumerate the principal objects embraced in the survey and shown in the plan. In the foreground is seen the Schuylkill River, curving first to the left around Turtle Rock and then to the right and falling over the dam into tide-water. On the right bank of the river we see the last lock of the Schuylkill Navigation, while in the immediate foreground is the Pennsylvania Railroad, intersected by the base-line. The tool house T, on the north side of the railroad, is one of the objects sighted (see View A_1). On the left bank of the river we have Lemon Hill, indicated by the contours. Along its foot are ranged the Skating Club House S and the Boat Club Houses to the right of it. On its left is the Turtle Rock Lighthouse L, just above which is seen the summer house H. Higher up, to the right, is the mansion M;

* See "Topographical Surveying," Van Nostrand's Science Series, No. 72.

† "Photography Applied to Surveying." By Lieut. Henry A. Reed. Second Edition. New York: John Wiley & Sons. 4to, $2 50.

and still higher, to the left, is the observatory O. On the extreme right of the plan, at the east end of the dam, are the Fairmount water works.

Beyond the plan and the survey the following objects appear in the photographic views: in A_1, the "Permanent Building," "Art Gallery" or "Memorial Hall" of the Centennial Exhibition, now occupied by the Pennsylvania Museum and School of Industrial Art; in A_1 and A_2, Girard Avenue Bridge, crossing the Schuylkill about half a mile above Turtle Rock; in A_2, just over the summer house H, the stand-pipe of the Spring Garden Water Works, and in A_4, Girard College and other buildings in the northern and northwestern parts of the city.

In the inside of the rear frame of the camera four needle-points were inserted,* one in the middle of each of the four sides. These projected into the field of view and were photographed on the plate, thus indicating the horizon and the middle vertical: and lines joining these points were drawn upon the ground-glass focusing screen, to aid in "pointing" the camera. In this operation the image of some prominent object in the field was superposed on the middle vertical of the ground-glass screen, and the magnetic bearing of the view read to the object itself. For this purpose it is convenient to have a small Casella's prismatic compass attached to the top of the camera, and the reading should be taken immediately after the exposure and before the instrument is disturbed by withdrawing the plate-holder.

Since all the points to be located were more than 100 yards distant, the focal length was practically a constant quantity (13.86 inches in this case), and a mark had previously been made on the sliding bed of the camera to indicate when the focal adjustment was correct.

With the instrument placed first at station A at the east end of the base-line, the four views, A_1, A_2, A_3, A_4† (beginning at the left), were taken; next, moving to B, three views, B_1, B_2, B_3, were taken (the last not shown); and, finally, as a check, and in

* Three of these needle-points are indicated in view A_1 at the left of the plate.

† The views taken from each station were made to embrace the entire sector (of horizon and intervening landscape) which it was desired to survey from such station, and to overlap each other by half an inch or more. For each view the camera was carefully leveled by means of a spirit level laid upon its top.

order to locate certain objects not visible from stations A and B, two views, C_1, C_2, were taken from station C, upon the top of a stone arch rising at the base of the Fairmount reservoir. The line AC was measured by triangulation. Each line of sight from each station was oriented by means of the compass. This completed the field work, of which the following notes were recorded:

PHOTOGRAPHIC SURVEY OF FAIRMOUNT AND VICINITY.

STATION.	NO. OF VIEW.	HEIGHT OF INSTRUMENT.*	BEARING.†	REMARKS.‡
A	1	4.5 feet.	329.25°	To gable of tool-house *T*, on Pennsylvania Railroad.
	2		4.25°	To summer house *H*, on Turtle Rock.
	3		40.00°	To right-hand end of gable of Bachelor's Barge Club House.
	4		77.50°	To chimney to the right of Catholic Church, at Seventeenth Street and Girard Avenue.
B	1	4.5 feet.	43.00°	To third window from west end of Skating Club House *S*.
	2		81.50°	To church spire west of Penitentiary.
	3		117.50°	To skylight of house on bluff. (This view is not shown in our plate.)
C	1	4.4 feet.	288.25°	To spire of building in line with N. W. corner of canal lock.
	2		326.25°	To west chimney of Lemon Hill Mansion *M*.

* Height of center of plate above ground.

† The Casella compass is graduated from 0° (north) through east, south and west to 360°.

‡ In the column of remarks it is well also to note the state of the weather and the time of exposure, especially when slow plates are used.

To apply the photographic views to the location of the points in the survey and to the construction of the plan, the base-line and the several lines of sight are first plotted in their relative positions by means of the compass bearings obtained in the field, and then upon each line of sight is laid off a constant distance AA_1, AA_2, BB_2, etc., equal to the focal length§ of the lens in the

§ The plan is drawn to any desired scale by simply plotting the base-line to that scale; but, inasmuch as the photographic views are necessarily used in their actual dimensions, they must be placed upon the sheet with their horizon lines at exactly the same distance (= the focal distance) from the point of view as they were from the lens in the field; otherwise the angles between the rays would evidently be incorrect. In our plate, the focal length and other dimensions are reduced to one-third of their actual values.

camera. At the points A_1, A_2, B_2, etc., thus established, the horizon lines hh' are then drawn at right angles to their lines of sight respectively. The photographs are now pinned by thumb tacks upon the sheet, their horizon lines and verticals corresponding with the horizon line hh' and the line of sight respectively. In our figure, for convenience of illustration, the outlines of the photographs are sketched in, and the plan is shown as if already made.

Suppose, for instance, that views A_2 and B_1 have been thus placed upon the sheet, and that it is desired by means of them to locate upon the plan the centers of the observatory O, and of the lighthouse L, and to ascertain the height of the former. We first project both of these points perpendicularly upon the horizon lines of the two views respectively, and then, from the points d, e, c, i, thus obtained, draw right lines or visual rays to the respective points of sight, A and B. The intersections O and L of these rays at once determine the positions of these two objects upon the plan, and the angles between the rays drawn to either one of the stations are the true horizontal angles between the objects at that station, as if they had been measured with a transit. In this way any other objects shown in the views may be readily located, and a plan thus constructed with any desired degree of detail.

Now, in order to ascertain the height of any object, as of the observatory O, draw ef (View B_1) perpendicular to the visual ray Be, and draw the hypothenuse Bf. From the observatory O, already located on the plan, draw Om perpendicular to the ray Be and terminating at the hypothenuse Bf. The length of Om gives the height of the observatory, on the scale of the plan. The same construction could be made on another sheet to a much larger scale and therefore with greater accuracy. Or, by calculation:

Height $Om = BO \times \frac{ef}{Be}$; $\frac{ef}{Be}$ being the tangent of the vertical angle fBe, and BO the distance from the observatory O to the point of view B.

If any station or point in the survey be fixed upon as a datum and its height found relatively to the horizon of any view, then the heights of points in this view, referred to this same horizon,

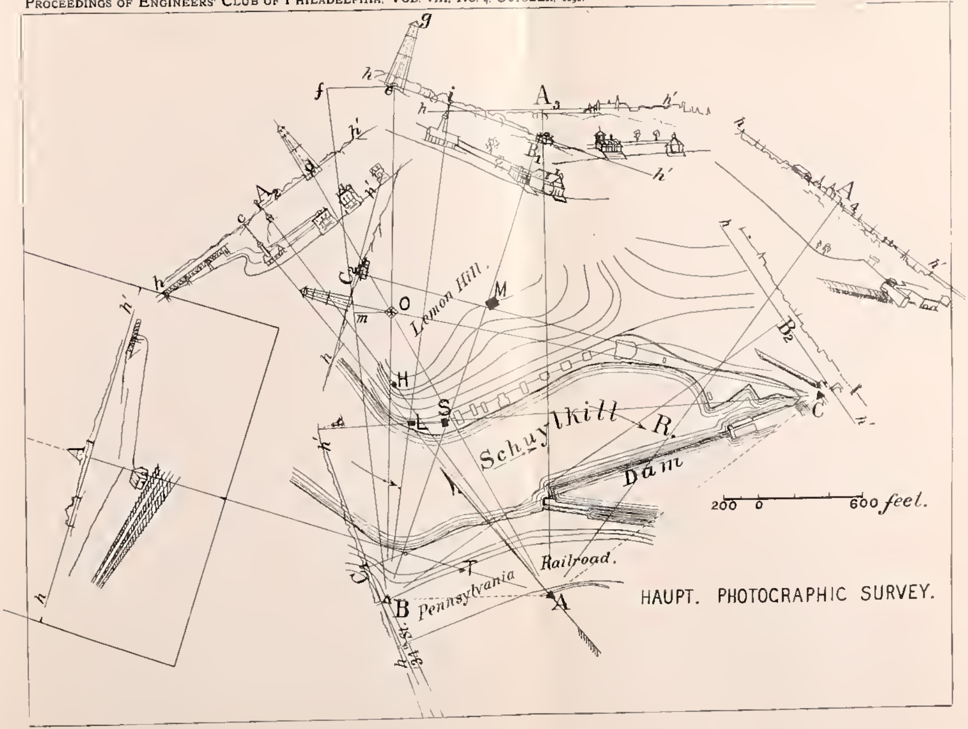
can easily be obtained with reference to the datum. In this way contour lines may be interpolated, and a complete topographical map be constructed, as by the ordinary methods.

The distance at which a point can be located with sufficient accuracy depends conjointly upon the focal length of the lens and upon the scale of the map. Col. Laussedat found that for scales between $\frac{1}{2000}$ and $\frac{1}{5000}$, a focal length of about 15 inches gave the most satisfactory results, while one of 12 inches was best adapted to scales between $\frac{1}{5000}$ and $\frac{1}{10000}$.

The measurement of heights depends entirely upon that of angles between visual rays, the method by intersections being here impracticable. Hence, the error in such measurements varies directly as the distance of the camera from the object, and inversely as the focal length of the lens. With delicate instruments, and with care, the measurement being taken from the negative and not from the print, the error can be made almost as small as may be desired. With an objective of 15-inch focus it should not average over 1 foot at a distance of 1,500 feet. When the same two points occur in any view, their relative heights should of course be deduced from the view taken from the *nearest* station; and, where considerable accuracy is desired and a choice of positions is offered, the nearest one to the object should be chosen; provided, of course, that it be not so near (say within 100 yards) as to affect the constancy of the focal length.

In the field work a number of practical considerations arise, relating to the character of the instruments used. With the ordinary wooden camera and light tripod, accurate leveling is impossible. Such work would be practicable only with the ideal surveying camera with metal parts and capable of adjustments similar to those of the transit. A substantial, well-made wooden camera is, however, well adapted for locating points horizontally and for rough contour work. A camera of this kind, size 8 x 10 inches, was used for the accompanying survey, and with remarkably satisfactory results as regards both accuracy and economy of time.

The time consumed in making the survey here described was not over half a day, and the data obtained afforded about a day's work in developing the negatives and subsequently plotting them.



HAUPT. PHOTOGRAPHIC SURVEY.

The results obtained were satisfactory, notwithstanding the rather large scale of 1 inch = 200 feet* used in making the plan.

As regards the manipulation of dry plates, full instructions are given by the makers of the several brands in the market. For our survey we used a moderately rapid (No. 23) Seed plate, with a small diaphragm in the lens. The weather was fine and the average exposure two seconds.

A slow hydrochinon developer was used, and especial care taken to bring out the details. After the negatives were dried, fine vertical and horizontal lines were scratched on the film joining the images of the needle points already referred to. These lines, representing respectively the middle vertical and the horizon line of the view, came out sharp and black on prints made from the negatives. Blue prints, pinned down to the board in the positions shown in the plate, were used for the platting, the negatives being consulted where special accuracy was desired.

The great economy of time in the field and the smallness of the necessary field party are arguments in favor of the photographic method. The photographer, with one or two assistants, would make up the party. The time taken for the survey depends upon the character of the country and upon the scale on which the platting is to be carried out. In Savoy, a survey of 30,000 acres took 18 days field work; another of 20,000 acres, 15 days; 110 views being taken in the latter instance. Contours were mapped 15 feet apart. For rapid military operations the photographic method would be invaluable, as evidenced by Lieut. Javary's work in Algiers. "In proportion as the survey is small and the greatest accuracy is desirable, the photographic method loses its superiority. But for large surveys its advantages are unquestionable, and in all cases may be made a valuable source of contribution to those details which would otherwise demand a long and tedious direct observation."†

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*In our plate this is reduced to 1 inch = 600 feet.

† Prof. A. S. Hardy in Van Nostrand's *Magazine*, May, 1875.

XXVIII.

ROADS.

By Thomas G. Janvier, Active Member of the Club.

Read April 4, 1891.

In considering the different features of the road question, it would be impossible to give rules or a set of specifications and directions to govern every case. In place of this a general form could be given, to be used as a guide, which, with some modifications, could be made to suit any particular locality.

Engineering Features.

This branch of the road question may be divided into three parts: (1) Location; (2) preparing the roadbed; (3) laying the pavement.

(1) *Location.*—There are many points to be considered in locating a new road, and a few of the more important ones only will be noticed. First, the item of expense should be considered. In this connection, the grading, land damages, etc., should not be overlooked. If it is intended to connect two cities or large towns, the line should be as direct as possible, remembering that a slight deflection to the right or left, or an easy curve, might save considerable expense in the matter of excavation, embankment or bridging.

If lying near to and intended to make communication with some railroad, it should, if possible, be either parallel with or at right angles to the same. If parallel with a railroad, the distance from it should be determined largely by the position of other roads running in the same direction. It should also be located so as to accommodate the greatest number of people living in the vicinity through which it is proposed to run. If the proposed road is at right angles to a railroad, it should be located nearly equidistant from roads on either side of the proposed location. In general, the road should be so located as to make the most direct and easy communication with a line of railroad or some prominent city or town, in order that the products of the farm, garden, etc., can be quickly put on the market.

The grades should be made as easy as possible, not to exceed seven feet in a hundred, except in very special cases, and for short distances, and not less than eight inches in a hundred. Excessive excavations and embankments should also be avoided, for as a general rule they tend to depreciate property on either side and present an unsightly appearance. The full width of the road should not be less than forty nor more than sixty feet; but the paved portion need be only from eighteen to twenty-four feet—eighteen feet being ample for the majority of country roads.

(2) *Preparing the Roadbed.*—When the location and width have been decided upon, accurate profile and cross-section plans should be made and the grade established. The drainage area on each side, for at least a mile, should also be studied, in order to provide ample culverts, drains, etc. The roadbed should be carefully brought to subgrade, one foot, more or less, as may be required, below finished grade. The longitudinal section must be of the same shape as the finished pavement, and the transverse or cross-section also, in order to afford better drainage, so that any water which might get through the pavement may pass off quickly from the center of the roadbed. If the cross-section of the subgrade is level or without any crown, then the crown must be made up in the pavement. This method will be found more expensive, more tedious and less satisfactory than that of making the crown in the subgrade. While the minimum grade could be eight inches per hundred feet, one foot would be much better, for unless the side gutters are very carefully and accurately graded and kept clean, it will be impossible for the water to run off freely and quickly where the grade is so light; and this is a very important feature. The writer has built a road with a grade of only three inches in a hundred feet, and although the water was carried off he would not recommend it, unless the gutters could be paved with asphalt blocks or something equally smooth.

The crown of the road from the center to the sides should not be less than half an inch, or more than three-quarters of an inch, to the foot; less than the former would not give good drainage, and more than the latter would have a tendency to give a lateral

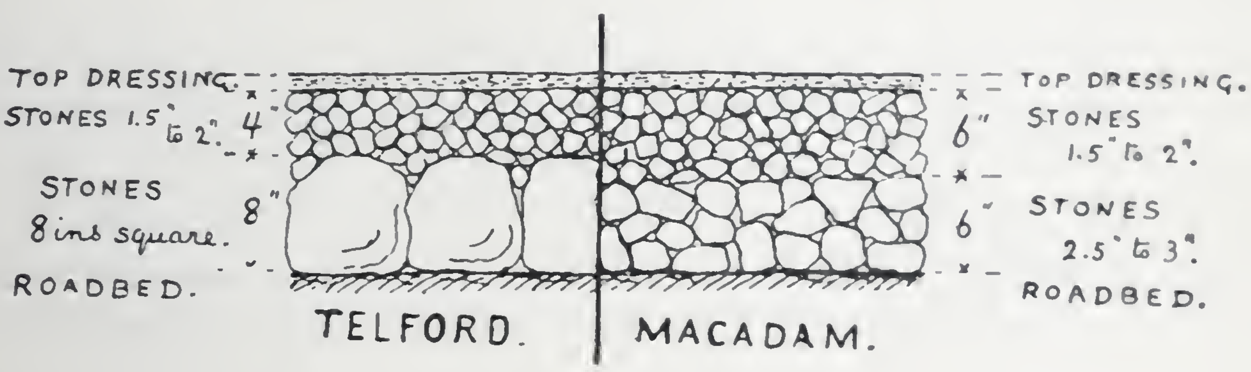
or sliding motion to vehicles, and thus injure the finished surface.

Where the road passes through a wet or springy soil, the latter should be carefully drained by means of suitable terra-cotta, tile or French drains. Drains laid in the shape of an inverted V, with the apex of the V pointing up the drive and located in the center, with its arms extending to the side-ditches, basins or other outlets, will give very satisfactory results. Where a road is entirely in excavation for a distance of twelve hundred feet or more, and there is no way of getting rid of the surface water, this can be advantageously done by having brick or stone silt basins with top grating and back inlet stone built at each side of the drive, about four hundred feet apart. These basins should be connected transversely, and on one side of the drive, longitudinally, by terra-cotta pipe laid not less than fifteen inches below subgrade. Iron pipe may be used for the transverse connections, and may be laid flush with or a few inches above subgrade. Where gravel can be reached at a reasonable depth, all the above pipes can be omitted by merely building the basins down to gravel and leaving the bottom open. In this case they should be larger, and not over two hundred feet apart.

Provision should be made to carry off quickly any water that might pass through the pavement to the subgrade of the road-bed. This can be done either by making connections with the basins, or, even where the road is slightly in embankment, by laying tile or French drains from the subgrade at the sides, through the shoulders or wings. These drains are particularly useful during construction and while the drive is green. They should always be put in at the low points of grade and elsewhere, as may be found necessary. Bridges and culverts should be built where necessary, and their construction, dimensions, etc., made to suit the locality, the drainage area, etc. One of the most important features, in either bridges or culverts, is the foundation. When rock or hard clay cannot be reached, or where quicksands are found, a good, durable and inexpensive bed for the masonry can be made with one and a half or two-inch hemlock plank laid in double courses, the lower one placed lengthwise with the

wall and the planks of full length, fourteen to sixteen feet; the top course should be at right angles to the lower one, and cut in such lengths as the thickness of the wall requires. This timber bed should extend two or three inches beyond the face, back and ends of the wall. It is entirely practical for moderately heavy walls, if there is a certainty of its being always covered with water. Where the drainage area is not very large, terra-cotta pipe may take the place of a culvert; but it is less durable, and its use is poor economy.

(3) *Laying the Pavement.*—The two methods in general use for making road pavements are the Telford and Macadam. They differ chiefly in the character of the foundation or bottom course.



(*a*) TELFORD.

The construction of the Telford pavement may be divided into three parts: (1) Foundation; (2) broken-stone covering; (3) top-dressing.

(1) *Foundation.*—The foundation should be composed of irregularly shaped, hard, tough and durable stones, from eight to twelve inches long, four to six inches wide, and eight to twelve inches deep, according to the depth of the pavement, being as nearly as possible of the same depth for a given depth of pavement. These stones should be carefully placed by hand lengthwise across the road, their broadest edges down and breaking joints as far as possible. All irregularities of the upper part of said foundation should be broken off with a napping hammer, and the interstices filled with stone chips, thus making a smooth, firm and even pavement.

(2) *Covering.*—Upon the foundation thus prepared a layer of broken stone from $1\frac{1}{2}$ to $2\frac{1}{2}$ inches in size, according to its hard-

ness, should be evenly spread to the depth of 4 inches, and thoroughly and repeatedly rolled with a roller weighing at least $2\frac{1}{2}$ tons. The stone for this covering should be the very best obtainable as regards hardness, toughness and power to resist abrasion and the action of the weather, for upon it will come the wear and tear of travel. For this purpose any of the trap rocks, granite or rock of a like character will be found to give entire satisfaction; and, although costing more at first, will be found much cheaper in the end than some of the softer stones. Practical experience and exhaustive tests have proved this beyond any doubt. A very light coat of clay upon this covering will be found advantageous in binding it to the top-dressing, and should be applied during the rolling.

(3) *Top-Dressing.*—A light top-dressing of stone screenings should be evenly spread over the broken stone covering, well sprinkled and thoroughly and repeatedly rolled with a steam roller weighing from 15 to 25 tons. The sprinkling should be kept up during the rolling, and the rolling continued until the surface becomes perfectly hard and smooth. The rolling should begin at the sides and be continued toward the center, up one side and down the other, so as to keep the crown well up. Where the road is in embankment it is important that the shoulders or wings on each side of the pavement should be well formed and thoroughly rolled, and thus made to serve as a backing to the pavement. When the finances will permit, rubble or cobble gutters from two to three feet wide should be laid on each side of the pavement. These will facilitate the surface drainage and prevent the washing away of the wings.

(*b*) Macadam.

The roadbed or subgrade for a Macadam pavement should be prepared in the same manner as for the Telford, but there is no foundation of squared stones as there is in the Telford. Upon the roadbed or subgrade a layer of broken stone from $2\frac{1}{2}$ to 3 inches in size is evenly spread to the depth of 6 inches; this is covered with a 6-inch layer of stones from $1\frac{1}{2}$ to 2 inches in size, and the whole thoroughly rolled; then a light coat of clay is applied, and this is covered with stone screenings, sprinkled and thoroughly rolled, as before described.

There is much difference of opinion as to which of these two methods is the best for a general road pavement; but there should not be to anyone who has watched the results of heavy travel upon Telford and Macadam pavements when laid on similar soil and under similar conditions. It will be found that ruts form sooner in the Macadam than in the Telford pavement, especially in the spring of the year. One reason for this is that the large foundation stones of the Telford present a greater surface of resistance to compression into the soil of the subgrade. The Macadam pavement is excellent for light travel, but is not equal to the Telford for general traffic.

A much cheaper road than either of the above can be made by using the Telford foundation and covering it with about four inches of gravel, containing sufficient clay to make it pack well. This makes a hard and smooth surface, is easily kept in repair, and is an excellent road for light travel.

A good road for eight months of the year can be made by placing about four inches of gravel upon the soil of the subgrade mentioned herein. Both of these gravel roads require rolling, shaping, etc.

Cost of the Above Pavements.

It is impossible to give the actual cost of any road improvement until a survey has been made, but an approximate estimate can be given from a careful preliminary observation.

The cost of earth excavation will be from 16 to 30 cents per cubic yard, according to the nature of the soil, the length of haul and the depth of cut.

Rock excavation costs from 50 to 75 cents per cubic yard. Stones suitable for a Telford foundation can be quarried and delivered on the work, provided a quarry is conveniently near, for $1 per cubic yard; or, for an 8-inch foundation, allowing for waste, about 22 cents per square yard. Four good pavers can readily place 300 lineal feet of foundation, 18 feet wide, in a day; and these, at $1.25 per day, and a foreman at $2, will bring the cost of laying the foundation to 2⅓ cents per square yard. Broken stone from the same quarry can be delivered for $1.25 per cubic yard, or about 14 cents per square yard 4 inches deep. The

minimum cost per square yard of a Telford pavement is about as follows:

Quarrying, delivering and placing foundation stones,	25 cts. per sq. yard.
" " " broken stone covering,	14 " "
Screening, sprinkling, rolling, etc.,	7 " "
Total cost of a square yard of Telford pavement under the most favorable conditions,	46 cts.

Under other conditions the cost per square yard may reach 95 cents. The latter figure allows for the very best stones, transported by cars and then hauled. To these figures must be added the cost of grading, draining, bridging, etc.

There is comparatively little difference between the cost of a Telford and that of a Macadam road of the same depth. A road made by putting four inches of gravel on a Telford foundation will cost about 35 cents per square yard, exclusive of grading, etc.

A gravel road on the natural soil of the subgrade can be made for about 10 cents per square yard, exclusive of grading, etc., etc.

Reconstruction.

A Telford or Macadam road, thoroughly constructed and properly maintained, will never require reconstruction; but there are roads, such as some of our old pikes, having from eight to ten ruts their entire length, said ruts being from two to four inches wide and three to six inches deep, which need it badly.

The best method for the reconstruction of such a road, when there is much of a deposit of mud and dirt, is: first to remove this deposit, then place upon the pike broken stone, four inches deep at the sides and six inches at the center, thus giving a crown of four inches. These stones should be put on in two layers, the lower one consisting of stones from 2 to $2\frac{1}{2}$ inches in size, and the upper one from $1\frac{1}{2}$ to 2 inches, according to their hardness; screenings should then be put on, sprinkled, rolled, etc., as in the Telford pavement. Where a change of grade may be found desirable, it is best to put down the Telford pavement after such a portion has been properly brought to subgrade. The drainage system should also be improved where necessary.

The cost of such reconstruction, exclusive of the Telford por-

tions and drainage, will be from thirty to forty-five cents per square yard, depending upon the cost of the broken stone delivered along the road.

Maintenance.

The best system for maintaining a Telford or Macadam road for ordinary travel is that of constant daily attention and repairs. All mud and dirt should be removed, so as to expose the surface of the pavement. In dry weather it should be sprinkled several times a day. This prevents the top-dressing from blowing away and helps to keep the pavement firm and solid; for if it becomes very dry it will soon bake, become loose and disintegrate. Too much water put on at one time has a tendency to soften and loosen the pavement. If possible, ruts should never be permitted to form, but this can be prevented only by constant attention. As soon as there is an indication of a rut the loose detritus from the adjacent parts of the road should be raked or swept into it; this will soon become well packed by the travel. If a rut forms, a horse will naturally follow it, and it becomes worse and worse. If a rut has formed, it should be filled at once flush with the pavement with 1 or $1\frac{1}{2}$-inch stones, as may be required. When the general surface requires patching, it should be done in small pieces, in order that the travel may not be driven away from the repairs, and that wagons will drive over and pack them at once. The best time to make such repairs is immediately after a rain, as they will then pack much better. If made in dry weather a sprinkler should be used. The frequent use of a $2\frac{1}{2}$-ton roller is invaluable for keeping a road in good shape and condition. For the purpose of making these repairs, $1\frac{1}{2}$-inch stones and screenings should be kept on hand at several points along the drive.

It is also important that the side ditches or gutters and all drains and inlets should be kept open and in good shape, so that the surface water may run off quickly. It is also important that all dirt roads intersecting a paved road should be paved for a distance of two or three hundred feet from the intersection, in order that as little mud as possible shall be carried on to the paved road.

The following are important points to be observed in the maintenance of a road:

(1) All mud and dirt must be removed as frequently as possible.

(2) The entire drainage system must be carefully maintained.

(3) Constant and daily repairs and patches wherever and whenever ruts or depressions begin to show.

(4) Careful sprinkling at least three or four times a day in dry weather.

(5) The frequent use of a $2\frac{1}{2}$-ton roller.

Gilmore gives the following results of daily repairs made upon a road of ordinary or moderate travel, as ascertained after exhaustive tests by French engineers: "It was found that in proportion as the interval between the periods of repairs was shortened upon such roads (about 600 tons being the daily tonnage of travel), the annual expense was lessened ; and the roads were always in better condition ; and finally, that the roads were never so good or the expense of maintenance so small as when the system of unremitting and minute attention was in full operation. . . . The road from Tours to Caen, which had been the subject of occasional repairs from 1832 to 1836 at an annual cost of £978 for material and labor, was in such a bad condition that it required four horses to draw the mail coach, and the service was so severe on the horses that eleven died from overwork during the year. In 1838, when the system of constant and minute repairs was in full operation, only two horses were necessary to draw the same coach. Under this system, from 1837 to 1841, the annual cost for material and labor was £820, thus showing, under the new system, a saving of 12 per cent. per annum in the expenses and maintenance, and 250 per cent. in the amount of animal power required for a special item of traffic."

A road of very heavy traffic may require re-surfacing to the depth of three or four inches every five or six years, and when the length of the road is fifteen or twenty miles, it is better to re-surface two or three miles every year. This re-surfacing should be done in the same way as the finishing of a Telford pavement. As far as possible it should be done in the spring or fall, so as to have the advantage of the rainy season. The cost of such re-surfacing will be from from 20 to 35 cents per square

yard, according to the quality of the stone used and the facilities for obtaining it.

One man, with a pair of horses, sprinkling-wagon, roller, cart, etc., should be able to keep in good repair at least three to four miles of Telford road. During the spring, fall and winter months he should put on such new material as may be found necessary and keep the ditches or gutters cleaned out and the drainage system in good condition. During the summer months he should keep the road properly sprinkled and make such repairs as may be necessary.

Needed Reforms in Legislation.

(1) Abolish the present system of working out road taxes, and have them paid in cash.

(2) Each county should have a superintendent of roads, who should be either appointed or elected for a term of years and well paid for his services. Each township should have a supervisor, subject to and under the direction of the county superintendent.

(3) The road taxes for each township should be expended by the supervisor, who should be held accountable to the township board or other authorities for the wise, judicious and honest expenditure of all moneys placed in his hands. He should employ labor to the best advantage, but, other things being equal, preference should be given to home labor. He should file a proper bond for the faithful performance of all duties. He shall build such new roads, bridges, etc., as the township board may direct, and properly maintain the old roads.

(4) There should be a standard set of specifications for the construction of all the roads of the State, subject to such modifications as may be found necessary for special localities, counties or townships.

(5) The State should build two roads at right angles or nearly so, and as nearly through the center of the State as may be practicable. Each county should do the same; this would offer great inducements for the townships to build the shorter roads.

(6) The State should offer a yearly prize to the county having throughout the year the best ten or fifteen miles of road, and each county a prize to the township having the best mile or two.

The Advantages to be Derived from Improved Roads.

(1) It has been found by practical and thorough tests that the motive power of a horse on a good stone road is at least double what it is on a dirt road in good condition. What would be the proportion with the dirt road in bad condition, full of ruts, etc.?

(2) One horse can easily haul one ton at the rate of six miles an hour, on a level Telford road, in summer or in winter. How fast could he haul the same load over a dirt road in muddy weather, or when the frost is coming out of the ground? In other words, the farmer with two horses could haul over a good stone road as much grain, marketing, etc., as he could with four horses over a dirt road and in half the time, thus showing an immense saving both in animal power and in time.

(3) A good stone road will always be an inducement for men of business and others from the city, desiring country homes, to locate on the line of the same. These would bring others who would erect desirable dwellings and thus enhance the value of adjoining land; thus increasing the amount of travel and decreasing the per capita for road maintenance; bringing the consumers of all farm products to the farmers' doors. In a short time other roads would have to be opened, and old ones improved, and it would not be long before the entire section would insist upon and have the very best stone roads.

NOTES AND COMMUNICATIONS.

RAIL-JOINTS.

Note by the Publication Committee.—We present herewith abstracts of three papers on the subject of rail-joints, all submitted during the first half of the present year and two of them in June. Two of these papers describe three new designs for joints, while the third gives the results of experiments upon a fourth form of joint designed by the author, Mr. G. W. Creighton, and submitted to the Club in May, 1890. That three communications upon this one subject should present themselves for publication in a single number of our Proceedings, and that without any effort to elicit the sense of the members upon that subject, may be taken as indicating that the technical mind is now laboring with this problem; and this in turn must be regarded as a sign (if one were wanting) that our present forms of joint (and particularly the orthodox angle bar) fail to meet all the requirements of modern traffic, and that they have therefore, in a sense, outlived their usefulness. But it is, perhaps, still more significant that in all four of the designs here described reliance is placed upon *a deep girder-like support beneath the base of the rail* and occupying, of course, only the short space between the two joint-ties. In three out of the four designs this support has a cross-section resembling either the whole, or the flange and half the web, of an inverted T-rail, while in the fourth form (which is a later modification of one of the others) this particular form of sub-rail support was abandoned only in order to secure greater facility of manufacture.

This tendency to revert to a principle employed in joints used by our ancestors and long since abandoned, seems to fly in the face of established precedent, but, judging from what follows, it appears to indicate the direction in which the solution of the rail-joint problem is now being sought.

The Heath joint, which has recently appeared, resembles the one here proposed by Mr. J. B. Walker, in having a cast girder with a curved lower flange, but in the Heath joint the girder has longitudinal prolongations which rest upon the joint-ties, and an upward projection supporting one side of the rail-head, after the manner of a single angle splice-bar. It further differs from Mr. Walker's joint in using bolts, while Mr. Walker's enjoys the distinction of being "boltless," except for a U-bolt which takes no sensible strain, but merely holds the parts in place.

A BOLTLESS RAIL-JOINT.

Regular Meeting, February 7, 1891.—The Secretary presented, for Mr. J. M. Stewart, Active Member of the Club, an illustrated description of a rail-joint, invented and patented by Mr. J. Bernard Walker, of Corvallis, Oregon. See Plate 2.

The principal feature in this joint is the cast-steel girder *G*. This girder, as shown in Fig. 2, has a central cross-section resembling that of an inverted and heavy T-rail, and its bottom flange curves upward toward each end (see Figs. 1 and 5). The girder is provided, at each end, with a pair of jaws, which embrace the two rails as shown in Figs. 1 and 4. The top flange has, at the middle of its length, a raised portion *C*, upon which rests a movable seat *E* when the joint is in place.

To place the joint in position (see Fig. 5), the movable seat E is first placed upon the recessed or lower portion D of the top flange of the girder, near either one of the two jaws. When in this position, there is a clearance between the top of the seat E and the base of the rail, sufficient to enable the girder, with the seat, to be slid upon the end of one rail. This is done, and that rail is then laid in place, its joint-tie being temporarily driven out of place, transversely of the track, to make room for it. The girder is then slid along until the middle of its length coincides with the joint between the two rails, as in Figs. 1 and 4.*

The seat E is then driven into its place on the raised portion C at the middle of the top flange of the girder. When in this position it presses upward against the bases of the rails at their joint, while the jaws at the ends of the girder bear down upon the tops of the rail flanges at about one foot each way from the joint. This brings the rails and the joint to a snug bearing at their several points of contact, the rail-ends resting upon the seat E, and the jaws upon the rail flanges.

The U-bolt† (Figs. 1 and 5) is then dropped into place, passing (Fig. 2) through holes‡ in the flanges of the rails, in the seat E and in the top flanges of the girder G; and is secured by a split key beneath. The joint-tie which was driven out to make room for the laying of the rail with the girder attached, is then replaced; and this completes the operation.

The inventor claims for this joint:

(1) Great strength. The girder can be made as deep as desired.

(2) The absence of all screw fastenings. These, by becoming slack, would impair the strength of the joint. In the present case the joint proper is in one solid casting, and could become loose only by fracture.

(3) The joint, once put in, requires no care or maintenance. Unlike the splice-bar or articulated truss joints, it does not depend for its efficiency upon the "human element."

(4) Perfect level. The seat E acts as a surfacing or leveling plate; for the unloaded rail is pulled down by the jaws that embrace it, upon the seat E, with a leverage which increases with the approach of the load and which reaches its maximum at the moment when a wheel passes the opening, when the reactions at both rail-ends are equal. It thus prevents all longitudinal blows upon the ends of rails, both rails being leveled up upon a common and broad base.

(5) Perfect alignment. This is secured by the co-action of the jaws, at each end, with the flanges at the sides of the central seat E (see Fig. 4). And, seeing that this alignment is not dependent upon screw fastenings, it follows that the alignment, like the level, may, in a properly designed joint of this kind, be left to itself when once the joint is locked.

(6) This joint does not transmit longitudinal motion from rail to rail. It fulfills the condition of connecting and yet not connecting the rails. It makes them continuous for strength, but leaves them disconnected for expansion. There is no binding or clamping action except under a passing load.

The author recommends good tie-plates on each joint-tie.

---

* In Fig. 4, portions of the rails are removed in order to show the positions of the jaws and of the U-bolt.

† There is but one of these U-bolts to each joint. It adds no strength to the joint, but serves merely as a key to keep the rail-ends in the center of the joint.

‡ These holes are elongated, to allow for contraction and expansion.

CAST STEEL.

BOLTLESS RAILJOINT.

by J.B.Walker

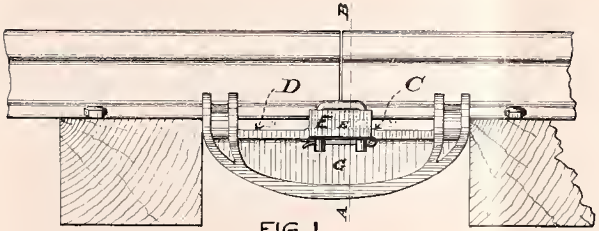
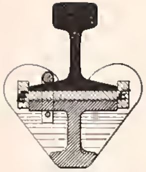
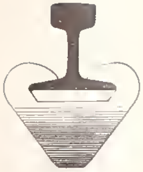


FIG. 1.



Section A B.

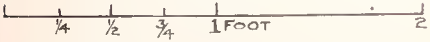
FIG. 2.



End View.

FIG. 3.

SCALE:



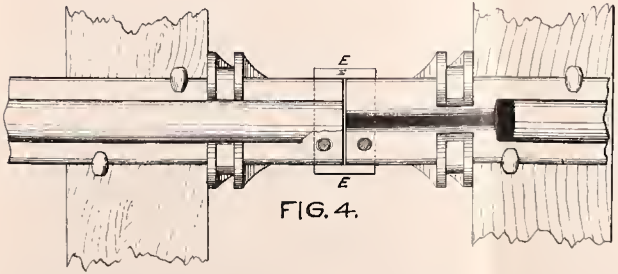


FIG. 4.

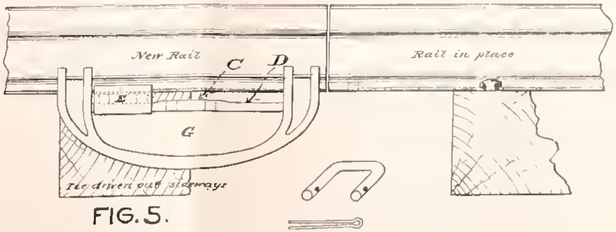


FIG. 5.

View showing method of attaching Joint.

COMPARATIVE EXPERIMENTS UPON THE STRENGTHS OF RAIL-JOINTS.

An Abstract of a Communication by G. W. Creighton, Presented June 6, 1891.—In the Club Proceedings for April of this year, Vol. VIII, No. 2, there appeared a paper, by Mr. Creighton, read May 17, 1890, describing a rail-joint which he had devised and which is represented in Fig. 6, Plate 2 *a*.

In the paper referred to, Mr. Creighton stated that the joint had not then been practically tested; but since then it has been subjected to test, not only in the track, but also in the Pennsylvania Railroad laboratory at Altoona. The results of the latter test are shown in the accompanying table, where they are compared with others, obtained: first, from a solid 85 pound rail, Pennsylvania Railroad standard, and second, from a Pennsylvania Railroad standard 34-inch six-hole angle-splice.

The "first series of tests" given in the table was made with one of Mr. Creighton's rail-joints that had been in service for eight months on the main passenger track of the Pennsylvania Railroad under 163 trains per twenty-four hours.

It will be observed that in the first test the joint was in the "normal" position (see upper figure), and was tested up to 42,000 pounds center load, with joints 20 inches apart; and that after this test the joint was turned upside down, and then, in this "reversed" position, tested up to the same point with loads applied as shown in the lower figure. The load was then again applied as in the normal position, and twice increased to 100,000 pounds (the limit of the machine), as shown under the third and fourth tests, but without breaking the joint.

The supports were then spread to 40 inches apart, and the loads increased up to 62,700 pounds at center, and under this load the joint broke, as shown at X X. This test is not shown in the table.

The second series of (two) tests (shown in the table) was then made, each test with a separate joint, and with supports 20 inches apart. As will be seen from the table, the joint again resisted the maximum load of the testing machine.

TRANSVERSE TESTS OF GEO. W. CREIGHTON'S RAIL-JOINT.

{ SUPPORTS 20 INCHES APART.
LOAD APPLIED AT CENTER.

LOAD POUNDS.	P. R. R. STANDARD STEEL RAIL.		STANDARD P. R. R. SPLICE.		CREIGHTON SPLICE—85-lb. Pattern.												LOAD POUNDS.
	85 lbs. per yard.		No. 6—Six holes, with 85-lb. rail.		First Series of Tests. One and the same pair of splices in the four tests.								Second Series of Tests. Separate splice for each test.				
					First: Normal.		Second: Rev'rsed		Third: Normal.		Fourth: Normal.		Normal.		Reversed.		
	Deflection.	Set.	Deflection.	Set.	Deflection.	Set.	Deflection.	Set.	Deflection.	Set.	Deflection.	Set.	Deflection.	Set.	Deflection.	Set.	
	inch.	inch.	inch.	inch.	inch.	inch.	inch.	inch.	inch.	inch.	inch.	inch.	inch.	inch.	inch.	inch.	
5,000			.002										.004				5,000
8,000	.003		.004		.003		.001										8,000
10,000	.004		.007		.009		.009	.002	.022		.029	.009	.009	.002	.003	.001	10,000
12,000	.003		.010		.009		.007										12,000
15,000			.014										.015	.004			15,000
16,000			.014	.001	.012	.000	.011	.006									16,000
18,000			.016		.013		.011										18,000
20,000	.004		.016		.014		.013		.042		.049	.012	.022	.002	.006	.001	20,000
22,000			.020		.016		.017										22,000
24,000			.021	.007	.019	.005	.019										24,000
25,000			.021										.028	.004			25,000
26,000	.006																26,000
27,000			.029		.018		.022										27,000
28,000	.011												.031	.004			28,000
30,000			.029	.015	.022		.024		.055		.073	.015	.034		.010	.002	30,000
35,000			.043	.024	.028	.005	.026						.038	.003			35,000
40,000			.051						.061		.076	.015	.047	.002	.019	.003	40,000
42,000	.014		.057	.026	.036	.007	.032	.014	.063								42,000
45,000			.069										.053	.004			45,000
50,000			.101						.070		.082	.015	.064	.005	.023	.002	50,000
52,000	.017																52,000
55,000			.149	.105									.068	.005			55,000
60,000	.020		.191						.078		.092	.015	.074	.008	.030	.003	60,000
65,000			.213										.079	.009			65,000
68,000	.023																68,000
70,000			.235						.082		.101	.015	.087	.012	.036	.003	70,000
75,000	.027												.090	.015			75,000
80,000	.028	.001	.305						.091		.107	.016	.095	.016	.046	.005	80,000
85,000	.029	.003	.366						.092				.102	.021			85,000
90,000	.031	.003	.443	.385					.095	.011	.111	.016	.110	.027	.064	.008	90,000
95,000			.659						.104				.120	.032			95,000
100,000	.032	.002	.671	.620					.107	.013	.120	.016	.130	.037	.072	.009	100,000

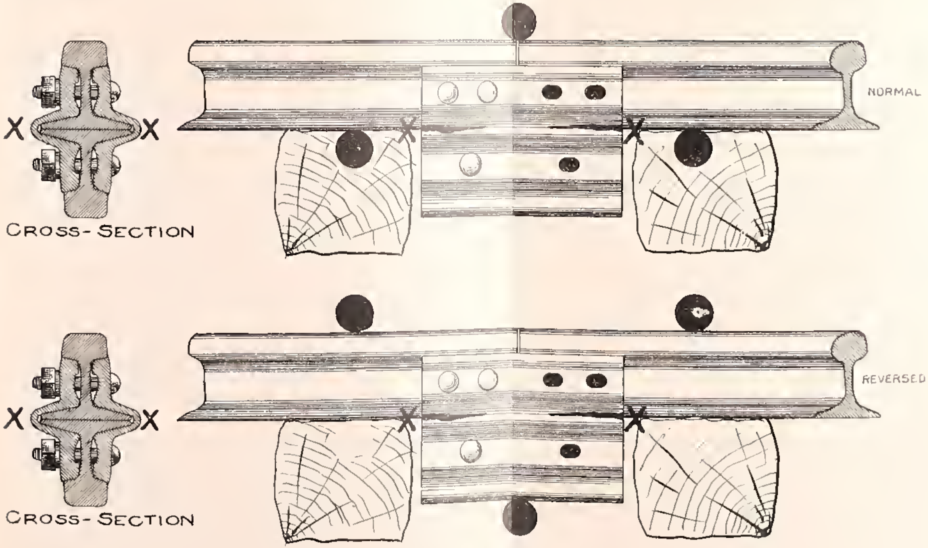
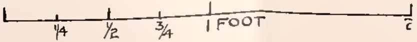


FIG. 6.

QUADRUPLE ANGLE SPLICE, DESIGNED BY G.W. CREIGHTON, OCTOBER 23RD 1889

SCALE:



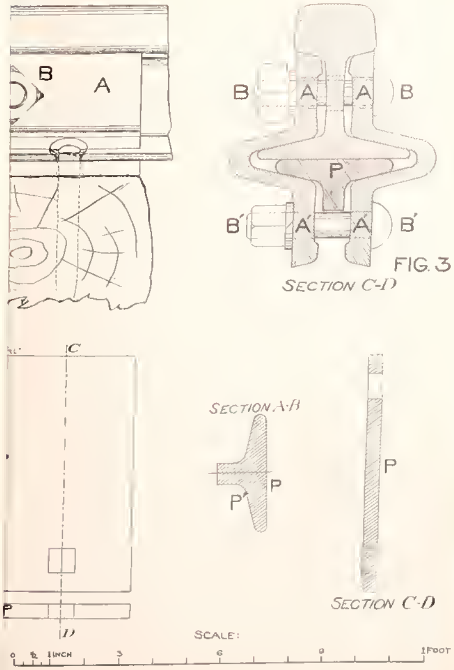


FIG. 3

A NEW RAIL-JOINT.

ABSTRACT OF A PAPER BY CHARLES S. CHURCHILL, READ JUNE 20, 1891.—At several recent meetings of railroad engineers, recommendations have been made that rail-joints should be so designed that the rail at the joint shall receive its support from beneath the base, instead of under the head, of the rail. These suggestions involve a condemnation of the angle-bar, as at present used, simply because it is not formed on correct principles, and therefore cannot secure the best results.

Angle-bar joints, even when of the most approved pattern and placed under heavy rails, show breaks in the angle-bars. The most recent observation I have made was within the last month, and on the Philadelphia, Wilmington and Baltimore Division of the Pennsylvania Railroad, between Philadelphia and Wilmington. There I noticed rails weighing, I think, about 85 pounds per yard and equipped with double angle-bars extending entirely across two ties and provided with six bolts; and I will venture to say that fully one-fifth of all the angle-bars on the section mentioned were broken directly at the joint, the break extending from the top of the bar downward. The fact that the bars failed in this manner proves conclusively that they broke, not when the weight of the wheel was directly over the joint, but when the wheels were between the two ties adjacent to the joint, or possibly still further away. Since nearly all angle-bars break in this way, it is of no advantage to lengthen them. What is wanted is an increase of section directly at the joint; but this increase cannot be secured, with the guarantee of a tight joint, unless the joint be carried *beneath* the rail.

Plate 3 shows a rail-joint (Design A), which I devised over a year ago, and which has been on trial for the past year on the Norfolk and Western Railroad. It will be noted that the joint consists of:

First.—A plate, PP (shown separately in Fig. 4), extending under the rail across both joint-ties, having a central rib projection, $P'P'$, directly under the joint.

Second.—Two angle-bars, AA, with a downward projection, $A'A'$, at center, so formed that they extend over the flange and under the rail, embracing the central rib $P'P'$ of the above-described plate PP.

Third.—Four bolts, BB, passing through the top of the angle-bar and the web of the rail, and two bolts, $B'B'$, passing through the lower part of the angle-bar underneath the rib projection of the plate.

The plate PP' acts, not only as a part of the joint, but also as a tie-plate.

In case these joints were manufactured in any great number, they would, no doubt, be made of wrought iron or steel. The joints which I have had on trial were made, for convenience, of cast steel. A section of track having a grade of 90 feet per mile and a number of 8° curves, the whole section ballasted with stone and laid with 67-pound rails, was equipped with this form of joint; while another section of track, adjacent to this one and like it in every other respect, was equipped with new angle-bars of our standard pattern. The new joints have now been in heavy service for a year, and no work has been required upon them. On the other hand, the angle-bar joints have required considerable tamping; and they do not, at this date, furnish as smooth a track as the new form of joint. I think, therefore, that the new form is fast proving itself a success. (See later note from author, page 306.)

Several points have come up, in connection with the economical manufacture of this joint, which have caused me to modify it slightly, the same principle in patent being used. The joint in its modified form (Design B) is shown in Plate 4.

In this form the central portion of the plate PP', instead of having but a single central projection, $P'P'$, as in Plate 3, is bent down along both edges, as shown very clearly in Figs. 8 and 9, Plate 4; and the angle bars AA' are also modified, as will be seen by comparing Fig. 3, Plate 3, with Fig. 8, Plate 4. This newer form of joint has not yet been tested in actual service.

It will be readily perceived that all parts of the joint shown in Plate 4 are so designed that they can be manufactured easily by the use of rolls and forge.

DISCUSSION.

By John C. Trautwine, Jr.—It may be of interest to note some points of resemblance and some of difference between the first * of the two joints suggested by Mr. Churchill and that † proposed by Mr. G. W. Creighton in his paper read May 17, 1890. As will be seen in the figures, both joints employ what may be called double angle-bars, each bar resembling *two* ordinary angle-bars, one of them inverted, and the two joined together at the point where the ordinary angle-bar rests upon the tie. In both joints these double angle-bars extend below the rail into the space between the joint-ties. In Mr. Creighton's joint the angle-bars below the track rail embrace a short piece of inverted T-rail (of the same pattern as the track rail), the upturned base of which abuts against the base of that of the track rail; while in Mr. Churchill's joint they embrace the central portion of a bridge plate, which projects downward between the joint-ties and has a cross-section resembling the flange and part of the stem of an inverted T-rail, the base of which (as in Mr. Creighton's joint) abuts against that of the track rail.

Mr. Creighton's joint, one foot long, is entirely confined to the space between two joint-ties, and is entirely supported by the rails themselves, having no bearing on the ties. In Mr. Churchill's joint the joint-ties are spaced only about 8 inches apart, and the central downward projection is only $7\frac{1}{4}$ inches long, but both the angle-bars and the plate referred to ($22\frac{1}{2}$ inches long) extend entirely across both of the joint-ties. The plate bears directly upon these ties, and the angle-bars bear, throughout their length, upon the upper side of the flanges of the rail.

FURTHER EXPERIENCE WITH MR. CHURCHILL'S RAIL-JOINT.

Extract from a Letter by Mr. Chas. S. Churchill, Dated Oct. 13, 1891. —Since I sent in my paper for discussion I have made another examination of the section of track equipped with my joint (Plate 3, Design A), and I find this piece of track in far better condition than that equipped with ordinary angle-bars. The slight depression which occurs at all the joints of rails fastened by angle-bars is absent from this section of track. Under traffic I noticed that the wave motion in the rails was carried through these joints practically as well as in the continuous rail. This, I think, is one of the best features of the joint, and is full proof of its success; for where this does not take place the joint is the weakest point in the track, and will soon become low, produce a rough track, and require constant attention.

I should have added in my paper that the joint is fully covered by patent issued early in 1890.

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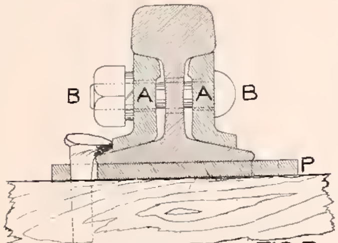
* Plate 3, Design A.

† Plate 2*a*, Fig. 6.

PROCEEDINGS OF ENGINEERS' CLUB OF PHILADELPHIA, VOL. VIII, NO 4, OCTOBER, 1891.



SECTION A-B FIG. 2

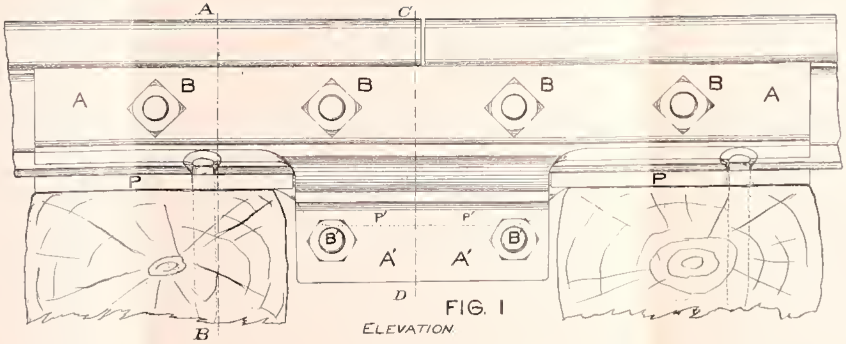


FIG. 1
ELEVATION.

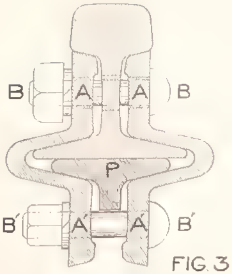


FIG. 3
SECTION C-D

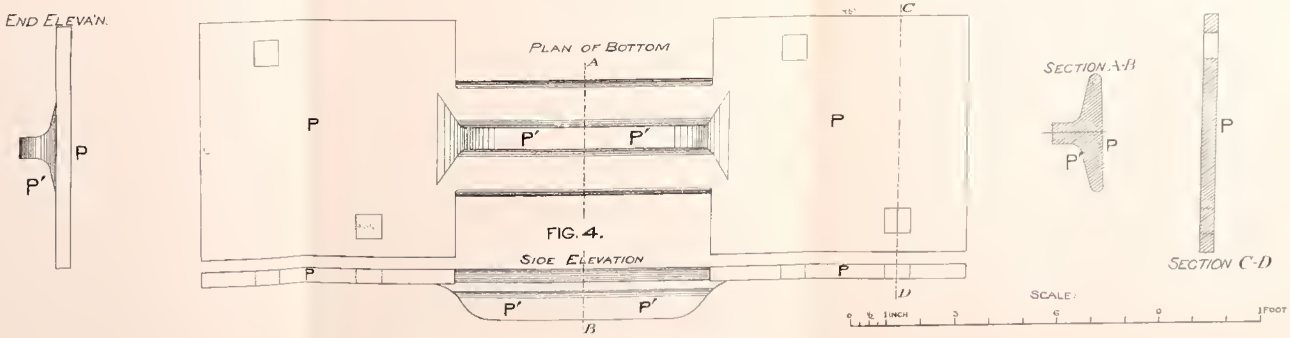


FIG. 4.

CHAS. S. CHURCHILL'S RAIL-JOINT, DESIGN A.

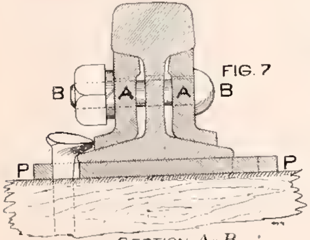
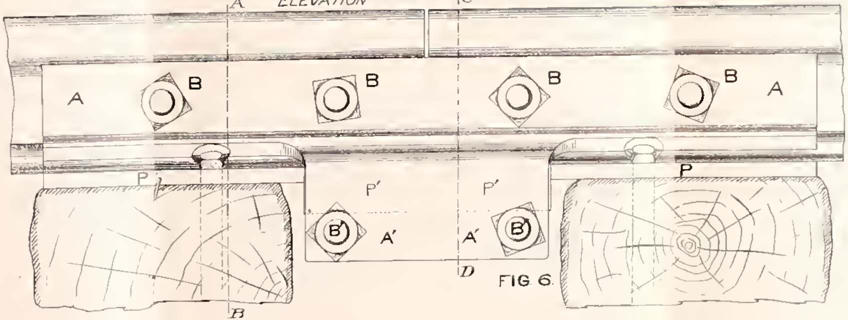


FIG. 7

SECTION A-B



ELEVATION

FIG. 6.

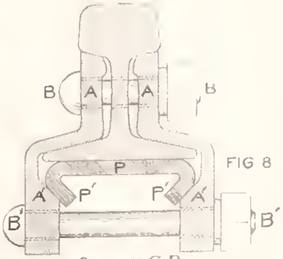
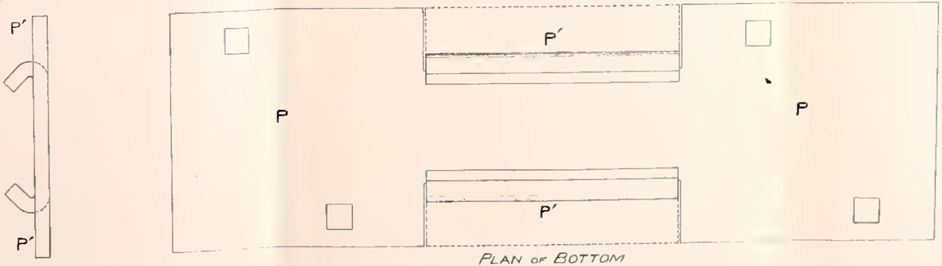


FIG 8

SECTION C-D

END ELEVA'N



PLAN OF BOTTOM

THE DOTTED LINES SHOW BOTTOM OF PLATE BEFORE BEING BENT

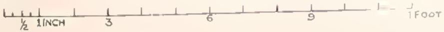


FIG. 9.

CHAS. S. CHURCHILL'S RAIL-JOINT, DESIGN B.

IMPROVEMENT OF THE MISSISSIPPI RIVER AT PLUM POINT REACH.

Regular Meeting, February 1, 1890.—Mr. Robert J. Parvin, visitor*, exhibited a set of twenty-three photographs† illustrating the progress of the work on the improvement of the Mississippi River at Plum Point Reach, under the charge of Captain Smith S. Leach.

The general plan of improvement proposed by the Board of Engineers on Improvement of Low-water Navigation of Mississippi and Missouri Rivers and set forth in Report of Chief of Engineers, U. S. Army, for 1879, Part II, Appendix M, was that of narrowing the channel by means of permeable dikes of piles and brush, etc., to an approximate low-water width of 3,500 feet. In addition to reduction of width, dredging was to be resorted to where the bed of the river was too hard to be worn by the current. Caving banks were to be protected.

This plan, with the addition of that of high-water control as the agency of low-water channel formation, was adopted by the Mississippi River Commission, organized under Act of Congress, approved June 28, 1879, as set forth in their first report (Report of Chief of Engineers, 1881, App. S. S.) and subsequent reports appearing annually in the same form.

All work done has been carried out under the auspices and upon the plan of this Commission.

It was decided that in order to test thoroughly the practicability and the cost of thus regulating the river and increasing its low-water depth, one of the worst places should be selected; and such a stretch was found in Plum Point Reach, between the States of Arkansas and Tennessee. The Reach is about 160 miles below the junction of the Ohio River at Cairo, Ill., and, according to the Report of the Chief of Engineers for 1883, extends "from about the head of Island 26 to Randolph, a distance of 38 miles." It "presents in many places excessive width, reaching 2 miles at high water and 1.5 miles at low water." It forms a portion of the First District, Mississippi River, which extends from Cairo to the foot of Island 40, a distance of 220 miles.

The photographs illustrate the various features in the work of narrowing the channel and securing and protecting the banks; such as hydraulic grading, the formation of revetments, weaving, ballasting and sinking sub-aqueous and connecting mats and the placing of stone upon them, etc. Two of the views show the operation of sinking drift by pumping sand upon it.

RUPTURE UNDER TENSION UNSYMMETRICALLY APPLIED.

Regular Meeting, June 6, 1891.—Prof. H. W. Spangler presented the following: A few days since, I was talking to our President, Mr. Wilfred Lewis, and he sketched a figure like Fig. 1 and said: "If this were a piece of uniform thickness and of homogeneous material and were pulled by a force W applied at the center of the end sections, where would it break?" I guessed, and of course incorrectly, and then suggested that he bring the matter before the Club. A few days afterward I received a letter from him, of which the following is the beginning: "The original

* Elected Associate Member June 21, 1890.

† These views have since been published in the Report of the Chief of Engineers, U. S. Army, for 1890, Part 4, Appendix F, now in the Club Library.

investigation of the strength of a flat bar of increasing width to one side of the line of strain, and the discovery that the weakest section in such a bar is 1.5 times the width of the section subject to uniform stress, should be credited to Mr. Carl G. Barth,* a Norwegian engineer, now in the employ of Wm. Sellers & Co., Incorporated. . . . . It was rather surprising to be told that, as the bar widened, it at first grew weaker and then stronger, and that the weakest section was 1.5 times the width of the original section subject to uniform stress; but an investigation of the problem showed that it yielded readily to the following analysis, which confirms the statement and shows how easily structures may be weakened by an abundance of badly disposed material."

In the following proof the lines laid out by Mr. Lewis are followed, but the matter has been somewhat enlarged upon.

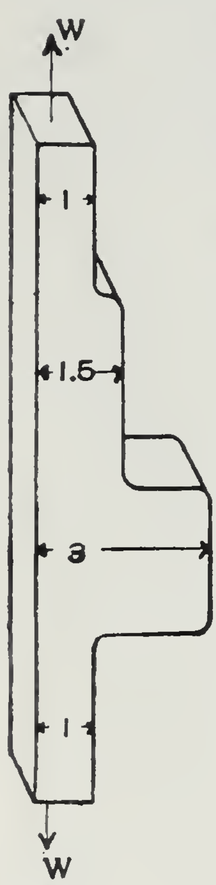


Fig. 1

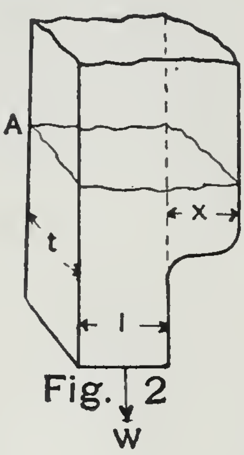


Fig. 2

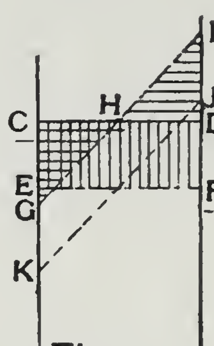


Fig. 3

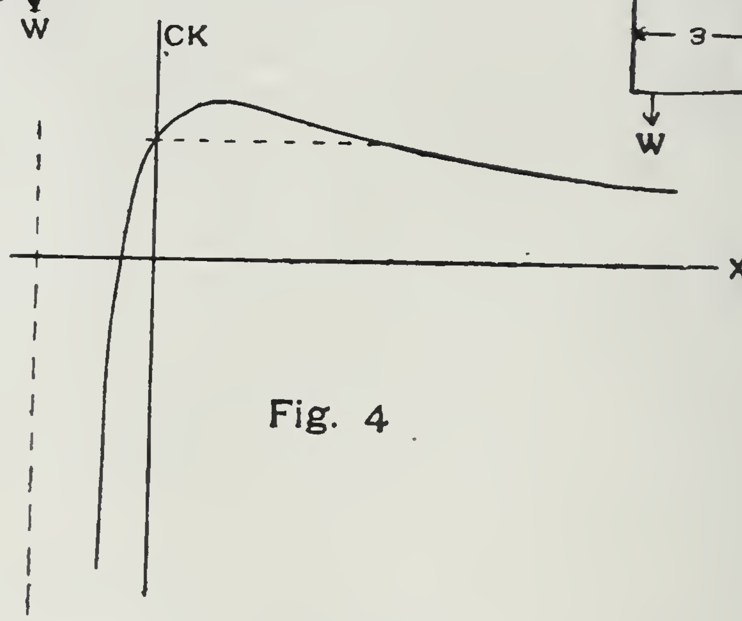


Fig. 4

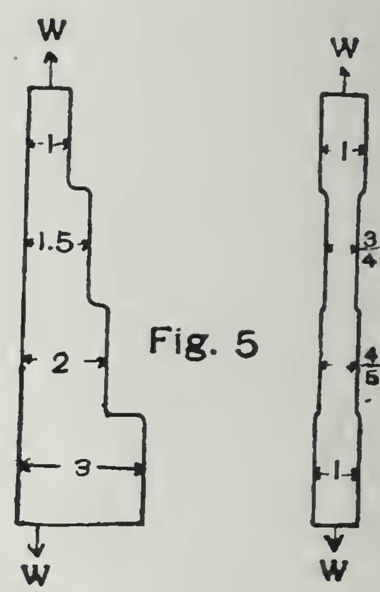


Fig. 5

In Fig. 2, calling t the uniform thickness of the piece, unity (1) the width of the part at the center of which the load is applied, and x the width added to one side of the bar, the area of the section AB is $(1 + x)\,t$, and a uniform tensile stress due to the weight W would be $\frac{W}{(1+x)\,t}$.

Fig. 3 is drawn to represent graphically the stresses acting on the section, the distance CD being $= 1 + x$. The uniform tensile stress can then be represented by a line, EF, whose distance from CD is $CE = DF = \frac{W}{(1+x)\,t}$.

The weight W does not act through the center of the section AB, but at a distance

* Admitted to the Club as an Active Member, October 17, 1891.

$\frac{x}{2}$ from the center, and there is therefore a bending moment $= W\frac{x}{2}$ acting on the section.

The resisting moment of this rectangular bar, acting as a beam, is

$$f\frac{(1+x)^2\,t}{6};$$

where f is the stress on the outer fibers;

or $$f\frac{(1+x)^2\,t}{6} = \frac{Wx}{2};$$

and $$f = \frac{3x}{(1+x)^2}\,\frac{W}{t}.$$

This value of f is represented in Fig. 3 by the distance CG; and the bending stress at all parts of the section is shown by the line GI passing through H, the center of the bar. The resultant stress, due to both the bending and the direct tension, is shown by the line KJ, where $CK = CE + CG$ and $JD = DF - DI$. Since the bar is only as strong as the outside fiber, we have, as the measure of the load on the bar:

$$CK = CE + CG = \frac{W}{t}\left\{\frac{1}{1+x} + \frac{3x}{(1+x)^2}\right\}.$$

Fig. 4 represents the values of CK for different values of x. It will be noticed that for $x = \frac{1}{2}$, the value of CK is a maximum, and for $x = 2$ it is the same as for $x = 0$, showing that, as material is added to one side of the bar, it becomes weaker until it is $1\frac{1}{2}$ times its original width, and is not as strong as it originally was until it has 3 times its original width.

To find that value of x which makes the load a maximum, taking the first differential of the equation for CK, and making it equal to zero, gives:

$$-\frac{1}{(1+x)^2} + \frac{3}{(1+x)^2} - \frac{6x}{(1+x)^3} = 0;$$

or: $$4x = 2$$

$$x = \tfrac{1}{2}.$$

Fig. 5 represents two bars of equal strength in each horizontal section, the addition of material on one side of the specimen having the same effect as reducing the size of the section as shown in the second bar.

RIVERMONT BRIDGE.

Business Meeting, February 21, 1891.—The Secretary presented, for Mr. Percy T. Osborne, a lithographic view of the Rivermont bridge at Lynchburg, Va.

The Rivermont Co. owns about 2,000 acres, lying northward of and partly within the city of Lynchburg, Va.; and the view represents a fine iron and steel highway bridge, built by the company in order to connect its property with the main street of the city.

The structure is $912\frac{1}{2}$ feet long, 60 feet wide and 126 feet above the water of the Blackwater creek, which it crosses. There are ten truss spans, as follows: one of 75 feet, one of 100 feet, one of 150 feet, and seven of $62\frac{1}{2}$ feet. The five towers are each 30 feet wide, measured on the center line of the bridge. The iron towers rest on masonry footings, and the foundations of some of those at the creek, on solid rock, are 20 feet below the surface.

The Norfolk and Western Railroad is crossed at a height of 98 feet. There are

1,700,000 lbs. of iron and steel in the bridge. The flooring for roadway consists of a layer of 3-inch heart pine plank, which is covered with a wearing floor of 2-inch oak plank, laid diagonally. The structure is proportioned for a live road of 100 pounds per square foot of roadway, and 80 pounds per square foot on sidewalks.

There are 2,683 cubic yards of masonry in the footings and two abutments. The total cost of the bridge, right of way, approaches, etc., is about $111,000. R. Taylor Gleaves was the Chief Engineer, and Percy T. Osborne Engineer in Charge. The Edge Moor Bridge Works of Delaware were the contractors for the superstructure. The masonry was built by John Kelly and others of Lynchburg. The structure was completed and opened to the public in the spring of this year (1891). It carries a double-track electric railway.

TESTING STEAM GAUGES.

Business Meeting, June 20, 1891.—Mr. H. W. Spangler presented the following communication: The testing of steam gauges, as usually done, is simply a comparison with some other gauge, which, at some other time, has been compared with a standard of some kind. The mercury column, the Shaw gauge, or some form of spring gauge is used as a standard. The mercury column is unhandy, and few are to be found that can be rapidly used. The Shaw gauge must be calibrated, and is no more a satisfactory standard than a good spring gauge. There is another apparatus that is often used in gauge testing, that is the square inch made by the Utica Steam Gauge Co. This is nothing more than a lever safety valve, having an area of one square inch, which can be loaded to any amount.

Not long since I saw in the works of the Crosby Steam Gauge Co. a device which was new to me,* and which seemed to me to be about the right thing for gauge testing, especially where much of it had to be done. Near one end of a small table or stand, a tube was set up vertically, and in this tube fitted a piston of exactly one-quarter-inch area. At the opposite end of the table was fitted a second vertical tube, to which is attached the gauge to be tested. These vertical tubes are connected by a small tube running under the table. To the center of this connecting tube a branch running to a reservoir is attached, the reservoir being higher than the top of either of the upright tubes. The top of the piston before spoken of, carries a flat circular disk, on which weights are placed as the testing proceeds.

The method of using the apparatus is as follows: The reservoir is first filled with oil, which is also allowed to fill the two vertical tubes. The gauge to be tested is attached to the vertical tube on one side of the table, and the piston is placed in the other vertical tube. The connection to the reservoir is closed, and weights are placed on the piston head, the corresponding pressure showing on the gauge. To eliminate the effect of friction between the piston and the tube, the piston and weights are given a rotary motion. It is found that if the gauge is tested both up and down the scale, the same weight on the piston always brings the pointer to exactly the same position.

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* I have since found a description and cut of this device in *Mechanics*, Vol. III, p. 227.

TABLE OF EQUIVALENTS OF CUBIC YARDS IN CUBIC FEET.

ROBERT A. CUMMINGS, October 17, 1890.

Cu. Yds.	Cu. Ft.	Cu. Yds.	Cu. Ft.	Cu. Yds.	Cu. Ft.	Cu. Yds.	Cu. Ft.	Cu. Yds.	Cu. Ft.	Cu. Yds.	Cu. Ft.
		4.0	108.0	**8.0**	216.0	**12.0**	324.0	**16.0**	432.0	**20.0**	540.0
0.1	2.7	4.1	110.7	8.1	218.7	12.1	326.7	16.1	434.7	20.1	542.7
0.2	5.4	4.2	113.4	8.2	221.4	12.2	329.4	16.2	437.4	20.2	545.4
0.3	8.1	4.3	116.1	8.3	224.1	12.3	332.1	16.3	440.1	20.3	548.1
0.4	10.8	4.4	118.8	8.4	226.8	12.4	334.8	16.4	442.8	20.4	550.8
0.5	13.5	4.5	121.5	8.5	229.5	12.5	337.5	16.5	445.5	20.5	553.5
0.6	16.2	4.6	124.2	8.6	232.2	12.6	340.2	16.6	448.2	20.6	556.2
0.7	18.9	4.7	126.9	8.7	234.9	12.7	342.9	16.7	450.9	20.7	558.9
0.8	21.6	4.8	129.6	8.8	237.6	12.8	345.6	16.8	453.6	20.8	561.6
0.9	24.3	4.9	132.3	8.9	240.3	12.9	348.3	16.9	456.3	20.9	564.3
1.0	27.0	**5.0**	135.0	**9.0**	243.0	**13.0**	351.0	**17.0**	459.0	**21.0**	567.0
1.1	29.7	5.1	137.7	9.1	245.7	13.1	353.7	17.1	461.7	21.1	569.7
1.2	32.4	5.2	140.4	9.2	248.4	13.2	356.4	17.2	464.4	21.2	572.4
1.3	35.1	5.3	143.1	9.3	251.1	13.3	359.1	17.3	467.1	21.3	575.1
1.4	37.8	5.4	145.8	9.4	253.8	13.4	361.8	17.4	469.8	21.4	577.8
1.5	40.5	5.5	148.5	9.5	256.5	13.5	364.5	17.5	472.5	21.5	580.5
1.6	43.2	5.6	151.2	9.6	259.2	13.6	367.2	17.6	475.2	21.6	583.2
1.7	45.9	5.7	153.9	9.7	261.9	13.7	369.9	17.7	477.9	21.7	585.9
1.8	48.6	5.8	156.6	9.8	264.6	13.8	372.6	17.8	480 6	21.8	588.6
1.9	51.3	5.9	159.3	9.9	267.3	13.9	375.3	17.9	483.3	21.9	591.3
2.0	54.0	**6.0**	162.0	**10.0**	270.0	**14.0**	378.0	**18.0**	486.0	**22.0**	594.0
2.1	56.7	6.1	164.7	10.1	272.7	14.1	380.7	18.1	488.7	22.1	596.7
2.2	59.4	6.2	167.4	10.2	275.4	14.2	383.4	18.2	491.4	22.2	599.4
2.3	62.1	6.3	170.1	10.3	278.1	14.3	386.1	18.3	494.1	22.3	602.1
2.4	64.8	6.4	172.8	10.4	280.8	14.4	388.8	18.4	496.8	22.4	604.8
2.5	67.5	6 5	175.5	10.5	283.5	14.5	391.5	18.5	499.5	22.5	607.5
2.6	70.2	6.6	178.2	10.6	286.2	14.6	394.2	18.6	502.2	22.6	610.2
2.7	72.9	6.7	180.9	10.7	288.9	14.7	396.9	18.7	504.9	22.7	612.9
2.8	75.6	6.8	183.6	10.8	291.6	14.8	399.6	18.8	507.6	22.8	615.6
2.9	78.3	6.9	186.3	10.9	294.3	14.9	402.3	18.9	510.3	22.9	618.3
3.0	81.0	**7.0**	189.0	**11.0**	297.0	**15.0**	405.0	**19.0**	513.0	**23.0**	621.0
3.1	83.7	7.1	191.7	11.1	299.7	15.1	407.7	19.1	515.7	23.1	623.7
3.2	86.4	7.2	194.4	11.2	302.4	15.2	410.4	19.2	518.4	23.2	626.4
3.3	89.1	7.3	197.1	11.3	305.1	15.3	413.1	19.3	521.1	23.3	629.1
3.4	91.8	7.4	199.8	11.4	307.8	15.4	415.8	19.4	523.8	23.4	631.8
3.5	94.5	7.5	202.5	11.5	310.5	15.5	418.5	19.5	526.5	23.5	634.5
3.6	97.2	7.6	205.2	11.6	313.2	15.6	421.2	19.6	529.2	23.6	637.2
3.7	99.9	7.7	207.9	11.7	315.9	15.7	423.9	19.7	531.9	23.7	639.9
3.8	102.6	7.8	210.6	11.8	318.6	15.8	426.6	19.8	534.6	23.8	642.6
3.9	105.3	7.9	213.3	11.9	321.3	15.9	429.3	19.9	537.3	23.9	645.3

Equivalents of Cubic Yards in Cubic Feet.—Page A.

Cu. Yds.	Cu. Ft.	Cu. Yds.	Cu. Ft.	Cu. Yds.	Cu. Ft.	Cu. Yds.	Cu. Ft.	Cu. Yds.	Cu. Ft.
24.0	648.0	**29.0**	783.0	**34.0**	918.0	**39.0**	1053.0	**44.0**	1188.0
24.1	650.7	29.1	785.7	34.1	920.7	39.1	1055.7	44.1	1190.7
24 2	653.4	29.2	788.4	34.2	923.4	39.2	1058.4	44.2	1193.4
24.3	656.1	29.3	791.1	34.3	926.1	39.3	1061.1	44.3	1196.1
24.4	658.8	29.4	793.8	34.4	928.8	39.4	1063.8	44.4	1198.8
24.5	661.5	29.5	796.5	34.5	931.5	39.5	1066.5	44.5	1201.5
24 6	664.2	29.6	799.2	34.6	934.2	39.6	1069.2	44.6	1204.2
24.7	666.9	29.7	801.9	34.7	936.9	39.7	1071.9	44.7	1206.9
24.8	669.6	29.8	804.6	34.8	939.6	39.8	1074.6	44.8	1209.6
24.9	672.3	29.9	807.3	34.9	942.3	39.9	1077.3	44.9	1212.3
25.0	675.0	**30.0**	810.0	**35.0**	945.0	**40.0**	1080.0	**45.0**	1215.0
25.1	677.7	30.1	812.7	35.1	947.7	40.1	1082.7	45.1	1217.7
25.2	680.4	30.2	815.4	35.2	950.4	40.2	1085.4	45.2	1220.4
25.3	683.1	30.3	818.1	35.3	953.1	40.3	1088.1	45.3	1223.1
25.4	685.8	30.4	820.8	35.4	955.8	40.4	1090.8	45.4	1225.8
25.5	688.5	30.5	823.5	35.5	958.5	40.5	1093.5	45.5	1228.5
25.6	691.2	30.6	826.2	35.6	961.2	40.6	1096.2	45.6	1231.2
25.7	693.9	30.7	828.9	35.7	963.9	40.7	1098.9	45.7	1233.9
25.8	696.6	30.8	831.6	35.8	966.6	40.8	1101.6	45.8	1236.6
25.9	699.3	30.9	834.3	35.9	969.3	40.9	1104.3	45.9	1239.3
26.0	702.0	**31.0**	837.0	**36.0**	972.0	**41.0**	1107.0	**46.0**	1242.0
26.1	704.7	31.1	839.7	36.1	974.7	41.1	1109.7	46.1	1244.7
26.2	707.4	31.2	842.4	36.2	977.4	41.2	1112.4	46.2	1247.4
26.3	710.1	31.3	845.1	36.3	980.1	41.3	1115.1	46.3	1250.1
26.4	712.8	31.4	847.8	36.4	982.8	41.4	1117.8	46.4	1252.8
26.5	715.5	31.5	850.5	36.5	985.5	41.5	1120.5	46.5	1255.5
26.6	718.2	31.6	853.2	36.6	988.2	41.6	1123.2	46.6	1258.2
26.7	720.9	31.7	855.9	36.7	990.9	41.7	1125.9	46.7	1260.9
26.8	723.6	31.8	858.6	36.8	993.6	41.8	1128.6	46.8	1263.6
26.9	726.3	31.9	861.3	36.9	996.3	41.9	1131.3	46.9	1266.3
27.0	729.0	**32.0**	864.0	**37.0**	999.0	**42.0**	1134.0	**47.0**	1269.0
27.1	731.7	32.1	866.7	37.1	1001.7	42.1	1136.7	47.1	1271.7
27.2	734.4	32.2	869.4	37.2	1004.4	42.2	1139.4	47.2	1274.4
27.3	737.1	32.3	872.1	37.3	1007.1	42.3	1142.1	47.3	1277.1
27.4	739.8	32.4	874.8	37.4	1009.8	42.4	1144.8	47.4	1279.8
27.5	742.5	32.5	877.5	37.5	1012.5	42.5	1147.5	47.5	1282.5
27.6	745.2	32.6	880.2	37.6	1015.2	42.6	1150.2	47.6	1285.2
27.7	747.9	32.7	882.9	37.7	1017.9	42.7	1152.9	47.7	1287.9
27.8	750.6	32.8	885.6	37.8	1020.6	42.8	1155.6	47.8	1290.6
27.9	753.3	32.9	888.3	37.9	1023.3	42.9	1158.3	47.9	1293.3
28.0	756.0	**33.0**	891.0	**38.0**	1026.0	**43.0**	1161.0	**48.0**	1296.0
28.1	758.7	33.1	893.7	38.1	1028.7	43.1	1163.7	48.1	1298.7
28.2	761.4	33.2	896.4	38.2	1031.4	43.2	1166.4	48.2	1301.4
28.3	764.1	33.3	899.1	38.3	1034.1	43.3	1169.1	42.3	1304.1
28.4	766.8	33.4	901.8	38.4	1036.8	43.4	1171.8	48.4	1306.8
28.5	769.5	33.5	904.5	38.5	1039.5	43.5	1174.5	48.5	1309.5
28.6	772.2	33.6	907.2	38.6	1042.2	43.6	1177.2	48.6	1312.2
28.7	774.9	33.7	909.9	38.7	1044.9	43.7	1179.9	48.7	1314.9
28.8	777.6	33.8	912.6	38.8	1047.6	43.8	1182.6	48.8	1317.6
28.9	780.3	33.9	915.3	38.9	1050.3	43.9	1185.3	48.9	1320.3

Equivalents of Cubic Yards in Cubic Feet.—Page B.

Cu. Yds.	Cu. Ft.	Cu. Yds.	Cu. Ft.	Cu. Yds.	Cu. Ft.	Cu. Yds.	Cu. Ft.	Cu. Yds.	Cu. Ft.
49.0	1323.0	**54.0**	1458.0	**59.0**	1593.0	**64.0**	1728.0	**69.0**	1863.0
49.1	1325.7	54.1	1460.7	59.1	1595.7	64.1	1730.7	69.1	1865.7
49.2	1328.4	54.2	1463.4	59.2	1598.4	64.2	1733.4	69.2	1868.4
49.3	1331.1	54.3	1466.1	59.3	1601.1	64.3	1736.1	69.3	1871.1
49.4	1333.8	54.4	1468.8	59.4	1603.8	64.4	1738.8	69.4	1873.8
49.5	1336.5	54.5	1471.5	59.5	1606.5	64.5	1741.5	69.5	1876.5
49.6	1339.2	54.6	1474.2	59.6	1609.2	64.6	1744.2	69.6	1879.2
49.7	1341.9	54.7	1476.9	59.7	1611.9	64.7	1746.9	69.7	1881.9
49.8	1344.6	54.8	1479.6	59.8	1614.6	64.8	1749.6	69.8	1884.6
49.9	1347.3	54.9	1482.3	59.9	1617.3	64.9	1752.3	69.9	1887.3
50.0	1350.0	**55.0**	1485.0	**60.0**	1620.0	**65.0**	1755.0	**70.0**	1890.0
50.1	1352.7	55.1	1487.7	60.1	1622.7	65.1	1757.7	70.1	1892.7
50.2	1355.4	55.2	1490.4	60.2	1625.4	65.2	1760.4	70.2	1895.4
50.3	1358.1	55.3	1493.1	60.3	1628.1	65.3	1763.1	70.3	1898.1
50.4	1360.8	55.4	1495.8	60.4	1630.8	65.4	1765.8	70.4	1900.8
50.5	1363.5	55.5	1498.5	60.5	1633.5	65.5	1768.5	70.5	1903.5
50.6	1366.2	55.6	1501.2	60.6	1636.2	65.6	1771.2	70.6	1906.2
50.7	1368.9	55.7	1503.9	60.7	1638.9	65.7	1773.9	70.7	1908.9
50.8	1371.6	55.8	1506.6	60.8	1641.6	65.8	1776.6	70.8	1911.6
50.9	1374.3	55.9	1509.3	60.9	1644.3	65.9	1779.3	70.9	1914.3
51.0	1377.0	**56.0**	1512.0	**61.0**	1647.0	**66.0**	1782.0	**71.0**	1917.0
51.1	1379.7	56.1	1514.7	61.1	1649.7	66.1	1784.7	71.1	1919.7
51.2	1382.4	56.2	1517.4	61.2	1652.4	66.2	1787.4	71.2	1922.4
51.3	1385.1	56.3	1520.1	61.3	1655.1	66.3	1790.1	71.3	1925.1
51.4	1387.8	56.4	1522.8	61.4	1657.8	66.4	1792.8	71.4	1927.8
51.5	1390.5	56.5	1525.5	61.5	1660.5	66.5	1795.5	71.5	1930.5
51.6	1393.2	56.6	1528.2	61.6	1663.2	66.6	1798.2	71.6	1933.2
51.7	1395.9	56.7	1530.9	61.7	1665.9	66.7	1800.9	71.7	1935.9
51.8	1398.6	56.8	1533.6	61.8	1668.6	66.8	1803.6	71.8	1938.6
51.9	1401.3	56.9	1536.3	61.9	1671.3	66.9	1806.3	71.9	1941.3
52.0	1404.0	**57.0**	1539.0	**62.0**	1674.0	**67.0**	1809.0	**72.0**	1944.0
52.1	1406.7	57.1	1541.7	62.1	1676.7	67.1	1811.7	72.1	1946.7
52.2	1409.4	57.2	1544.4	62.2	1679.4	67.2	1814.4	72.2	1949.4
52.3	1412.1	57.3	1547.1	62.3	1682.1	67.3	1817.1	72.3	1952.1
52.4	1414.8	57.4	1549.8	62.4	1684.8	67.4	1819.8	72.4	1954.8
52.5	1417.5	57.5	1552.5	62.5	1687.5	67.5	1822.5	72.5	1957.5
52.6	1420.2	57.6	1555.2	62.6	1690.2	67.6	1825.2	72.6	1960.2
52.7	1422.9	57.7	1557.9	62.7	1692.9	67.7	1827.7	72.7	1962.9
52.8	1425.6	57.8	1560.6	62.8	1695.6	67.8	1830.6	72.8	1965.6
52.9	1428.3	57.9	1563.3	62.9	1698.3	67.9	1833.3	72.9	1968.3
53.0	1431.0	**58.0**	1566.0	**63.0**	1701.0	**68.0**	1836.0	**73.0**	1971.0
53.1	1433.7	58.1	1568.7	63.1	1703.7	68.1	1838.7	73.1	1973.7
53.2	1436.4	58.2	1571.4	63.2	1706.4	68.2	1841.4	73.2	1976.4
53.3	1439.1	58.3	1574.1	63.3	1709.1	68.3	1844.1	73.2	1979.1
53.4	1441.8	58.4	1576.8	63.4	1711.8	68.4	1846.8	73.4	1981.8
53.5	1444.5	58.5	1579.5	63.5	1714.5	68.5	1849.5	73.5	1984.5
53.6	1447.2	58.6	1582.2	63.6	1717.2	68.6	1852.2	73.6	1987.2
53.7	1449.9	58.7	1584.9	63.7	1719.9	68.7	1854.9	73.7	1989.9
53.8	1452.6	58.8	1587.6	63.8	1722.6	68.8	1857.6	73.8	1992.6
53.9	1455.3	58.9	1590.3	63.9	1725.3	68.9	1860.3	73.9	1995.3

Equivalents of Cubic Yards in Cubic Feet.—Page C.

Cu. Yds.	Cu. Ft.	Cu. Yds.	Cu. Ft.	Cu. Yds.	Cu. Ft.	Cu. Yds.	Cu. Ft.	Cu. Yds.	Cu. Ft.
74.0	1998.0	**79.0**	2133.0	**84.0**	2268.0	**89.0**	2403.0	**94 0**	2538.0
74.1	2000.7	79.1	2135.7	84.1	2270.7	89.1	2405.7	94.1	2540.7
74.2	2003.4	79.2	2138.4	84.2	2273.4	89.2	2408.4	94.2	2543.4
74.3	2006.1	79.3	2141.1	84.3	2276.1	89.3	2411.1	94.3	2546.1
74.4	2008.8	79.4	2143.8	84.4	2278.8	89.4	2413.8	94.4	2548.8
74.5	2011.5	79.5	2146.5	84.5	2281.5	89.5	2416.5	94.5	2551.5
74·6	2014.2	79.6	2149.2	84.6	2284.2	89.6	2419.2	94.6	2554.2
74.7	2016.9	79.7	2151.9	84.7	2286.9	89.7	2421.9	94.7	2556.9
74.8	2019.6	79.8	2154.6	84.8	2289.6	89.8	2424.6	94.8	2559.6
74.9	2022.3	79.9	2157.3	84.9	2292.3	89.9	2427.3	94.9	2562.3
75.0	2025.0	**80.0**	2160.0	**85.0**	2295.0	**90 0**	2430.0	**95.0**	2565.0
75.1	2027.7	80.1	2162.7	85.1	2297.7	90.1	2432.7	95.1	2567.7
75.2	2030.4	80.2	2165.4	85.2	2300.4	90.2	2435.4	95.2	2570.4
75.3	2033.1	80.3	2168.1	85.3	2303.1	90.3	2438.1	95.3	2573.1
75.4	2035.8	80.4	2170.8	85.4	2305.8	90.4	2440.8	95.4	2575.8
75.5	2038.5	80.5	2173.5	85.5	2308.5	90.5	2443.5	95.5	2578.5
75.6	2041.2	80.6	2176.2	85.6	2311.2	90.6	2446.2	95.6	2581.2
75.7	2043.9	80.7	2178.9	85.7	2313.9	90.7	2448.9	95.7	2583.9
75.8	2046.6	80.8	2181.6	85.8	2316.6	90.8	2451.6	95.8	2586.6
75.9	2049.3	80.9	2184.3	85.9	2319.3	90.9	2454.3	95.9	2589.3
76.0	2052.0	**81.0**	2187.0	**86.0**	2322.0	**91.0**	2457.0	**96.0**	2592.0
76.1	2054.7	81.1	2189.7	86.1	2324.7	91.1	2459.7	96.1	2594.7
76.2	2057.4	81.2	2192.4	86.2	2327.4	91.2	2462.4	96.2	2597.4
76.3	2060.1	81.3	2195.1	86.3	2330.1	91.3	2465.1	96.3	2600.1
76.4	2062.8	81.4	2197.8	86.4	2332 8	91.4	2467.8	96.4	2602.8
76.5	2065.5	81.5	2200.5	86.5	2335.5	91.5	2470.5	96.5	2605.5
76.6	2068.2	81.6	2203.2	86.6	2338.2	91.6	2473.2	96.6	2608.2
76.7	2070.9	81.7	2205.9	86.7	2340.9	91.7	2475.9	96.7	2610.9
76.8	2073.6	81.8	2208.6	86.8	2343.6	91.8	2478.6	96.8	2613.6
76.9	2076.3	81.9	2211.3	86.9	2346.3	91.9	2481.3	96.9	2616.3
77.0	2079.0	**82.0**	2214.0	**87.0**	2349.0	**92.0**	2484.0	**97.0**	2619.0
77.1	2081.7	82.1	2216.7	87.1	2351.7	92.1	2486.7	97.1	2621.7
77.2	2084.4	82.2	2219.4	87.2	2354.4	92.2	2489.4	97.2	2624.4
77.3	2087.1	82.3	2222.1	87.3	2357.1	92.3	2492.1	97.3	2627.1
77.4	2089.8	82.4	2224.8	87.4	2359.8	92.4	2494.8	97.4	2629.8
77.5	2092.5	82.5	2227.5	87.5	2362.5	92.5	2497.5	97.5	2632.5
77.6	2095.2	82.6	2230.2	87.6	2365.2	92.6	2500.2	97.6	2635.2
77.7	2097.9	82.7	2232.9	87.7	2367.9	92.7	2502.9	97.7	2637.9
77.8	2100.6	82.8	2235.6	87.8	2370.6	92.8	2505.6	97.8	2640.6
77.9	2103.3	82.9	2238.3	87.9	2373.3	92.9	2508.3	97.9	2643.3
78.0	2106.0	**83,0**	2241.0	**88.0**	2376.0	**93.0**	2511.0	**98.0**	2646.0
78.1	2108.7	83.1	2243.7	88.1	2378.7	93.1	2513.7	98.1	2648.7
78.2	2111.4	83.2	2246.4	88.2	2381.4	93.2	2516.4	98.2	2651.4
78.3	2114.1	83.3	2249.1	88.3	2384.1	93.3	2519.1	98.3	2654.1
78.4	2116.8	83.4	2251.8	88.4	2386.8	93.4	2521.8	98.4	2656.8
78.5	2119.5	83.5	2254.5	88.5	2389.5	93.5	2524.5	98.5	2659.5
78.6	2122.2	83.6	2257.2	88.6	2392.2	93.6	2527.2	98.6	2662.2
78.7	2124.9	83.7	2259.9	88.7	2394.9	93.7	2529.9	98.7	2664.9
78.8	2127.6	83.8	2262.6	88.8	2397.6	93.8	2532.6	98.8	2667.6
78.9	2130.3	83.9	2265.3	88.9	2400.3	93.9	2535.3	98.9	2670.3

Equivalents of Cubic Yards in Cubic Feet.—Page D.

Cu. Yds.	Cu. Ft.	Cu. Yds.	Cu. Ft.	Cu. Yds.	Cu. Ft.	Cu. Yds.	Cu. Ft.	Cu. Yds.	Cu. Ft.
99.0	2673.0	**100.0**	2700.0	**101.0**	2727.0	**102.0**	2754.0	**103.0**	2781.0
99.1	2675.7	100.1	2702.7	101.1	2729.7	102.1	2756.7	103.1	2783.7
99.2	2678.4	100.2	2705.4	101.2	2732.4	102.2	2759.4	103.2	2786.4
99.3	2681.1	100.3	2708.1	101.3	2735.1	102.3	2762.1	103.3	2789.1
99.4	2683.8	100.4	2710.8	101.4	2737.8	102.4	2764.8	103.4	2791.8
99.5	2686.5	100.5	2713.5	101.5	2740.5	102.5	2767.5	103.5	2794.5
99.6	2689.2	100.6	2716.2	101.6	2743.2	102.6	2770.2	103.6	2797.2
99.7	2691.9	100.7	2718.9	101.7	2745.9	102.7	2772.9	103.7	2799.9
99.8	2694.6	100.8	2721.6	101.8	2748.6	102.8	2775.6	103.8	2802.6
99.9	2697.3	100.9	2724.3	101.9	2751.3	102.9	2778.3	103.9	2805.3

TABLE OF EQUIVALENTS OF CUBIC FEET IN CUBIC YARDS.

Cu. Ft.	Cu. Yds.	Cu. Ft.	Cu. Yds.	Cu. Ft.	Cu. Yds.	Cu. Ft.	Cu. Yds.
.1	.00370	1	.0370	11	.407	21	.777
.2	.00740	2	.0740	12	.444	22	.814
.3	.01111	3	.111	13	.481	23	.851
.4	.01481	4	.148	14	.518	24	.888
.5	.01851	5	.185	15	.555	25	.925
.6	.02222	6	.222	16	.592	26	.962
.7	.02592	7	.259	17	.629	27	1.000
.8	.02962	8	.296	18	.666		
.9	.03333	9	.333	19	.703		
.10	.03730	10	.370	20	.740		

RATIOS BETWEEN THE CUBIC INCH, THE CUBIC FOOT AND THE CUBIC YARD.

	Cubic Inches.	Cubic Feet.	Cubic Yards
1 cubic inch . .	1	0.0005787037	0.00002143347+
1 cubic foot . . .	1728	1	0.037037
1 cubic yard . .	46,656	27	1

CONTRIBUTIONS TO THE LIBRARY.

FROM JUNE 30, 1891, TO OCTOBER 15, 1891.

(See also List of Exchanges, page 318.)

From the U. S. NAVY DEPARTMENT, Washington, D. C.

Report on Uniform System for Spelling Foreign Geographical Names.
Bulletin No. 3 of Board on Geographic Names, issued August 1, 1891.

From the SMITHSONIAN INSTITUTION, Washington, D. C.

Langley, S. P.—Experiments in Aerodynamics, 1891.
Proceedings and Transactions of the Nova Scotian Institute of Science, Halifax.—Vol. VII, Part 4, 1889–90.

From Mr. HARVEY B. CHESS.

Slow Combustion Construction of Buildings.

From Mr. J. JAMES R. CROES.

Report to the Board of Trade of the City of Johnstown, Pa., on the Rivers at Johnstown, Pa. (bound).

From Mr. PEDRO G. SALOM, Active Member of the Club.

Concerning Trusts—A Paper Read before the Philadelphia Social Science Association February 21, 1889, by Prof. R. E. Thompson.

From the INSTITUTION OF CIVIL ENGINEERS, London.

SELECTED PAPERS, AS FOLLOWS:

Fox—Irrigation in Southern California.
Atkinson, L. and C.—Electric Mining Machinery.
Good—Construction of the New Nadrai Aqueduct, Ganges Canal.
Hill—Counterbalancing of Locomotive Engines.
Marten—Sewerage of Dudley.
Pickwell—Petroleum Storage Installations.
Andrews—Effect of Temperature on the Strength of Railway Axles.
Carrington—Refined Petroleum in Bulk.
Crompton—Generation and Distribution of Electrical Energy.
Donkin—Temperature of Cylinders of Steam Engines.
Langdon—Railway Train Lighting.
Pearsall—Hydraulic Pumping Engine.
Sheibner—Florence and Fiesole Electric Railway.

Harrison—Subterranean Water in the Chalk Formation of the Upper Thames.
Eliot and Aytoun—Scarborough Improvement Works.
Harris—Skew-arch Course Traces.
Kidd—Construction of Piers and Breakwaters.
Redgrave—Manufacture and Properties of Slag Cement.
Tait—Lanarkshire and Ayrshire Railways.
Unwin—Transmission and Distribution of Power.
Urquhart—Communication in Trains.
Webster—Fireproof Construction.

LIST OF EXCHANGES.

(See also Contributions to the Library, page 316.)

The following list comprises the names which the Publication Committee finds entered upon the Club Exchange List, including those of some societies, educational institutions, etc., from whom little or no regular return is now received. The Committee will take an early opportunity to revise the list. In the meantime members are requested to send in the names of any desirable additions to it.

AMERICA.

UNITED STATES.

U. S. Government Departments and Institutions.

Coast and Geodetic Survey. U. S.——. Annual Reports (bound). Bulletins. Monthly Pilot Chart of North Atlantic Ocean.

Engineer Department, U. S. A. Annual Reports of the Chief of Engineers, U. S. A. (bound).

Engineer School. U. S.——. Willetts Point, New York Harbor.

Geological Survey. U. S.——. Annual Reports. Monographs.

Hydrographic Office, U. S.——. Philadelphia. Monthly Pilot Chart of North Atlantic Ocean.

Navy Department. U. S.——. Report of Chief of Bureau of Steam Engineering. Sundry papers. (See Contributions to Library, page 316.)

Patent Office, U. S.——. Patent Office Reports.

Smithsonian Institution. Annual Reports of the Board of Regents (bound). (See also Contributions to Library, page 316.)

Weather Bureau, U. S.——. Philadelphia. Daily Weather Charts.

State and Municipal Departments, etc.

Arkansas. State Geologist. Annual Reports.

Massachusetts. State Board of Health. Annual Reports.

Missouri. Geological Survey of——. Bulletins. Biennial Report of the State Geologist.

New Jersey. Geological Survey of——. Atlas. Annual Reports.

Pennsylvania. Department of Internal Affairs. Annual Report of the Secretary (bound).

Pennsylvania. Second Geological Survey of——. Reports (bound).

Philadelphia. Commissioners for the Erection of the Public Buildings. Reports and Proceedings.

Societies.

(*a*) national.

American Institute of Electrical Engineers, New York. Transactions, monthly.
" " " Mining Engineers. " "

American Iron and Steel Association, Philadelphia. Annual Statistical Report. Papers. List of Iron Works.

American Philosophical Society, Philadelphia. Proceedings, semi-annual.

" Shipmasters' Association, New York.

" Society of Civil Engineers, New York. Transactions, monthly.

" " for the Extension of University Teaching, Philadelphia. Journal.

" " of Mechanical Engineers, New York. Transactions, annual.

" Water Works Association. Reports of Annual Meetings.

Association of Engineering Societies, New York. Journal, monthly.

Master Car-Builders' Association, New York. Reports of Annual Conventions.

U. S. Association of Charcoal Iron Workers, Philadelphia. Journal, bi-monthly.

(*b*) SECTIONAL.

Engineering Association of the South, Nashville, Tenn.

Southern Society of Civil Engineers, Jacksonville, Fla. Proceedings.

Technical Society of the Pacific Coast, San Francisco, Cal. Transactions.

Western Society of Engineers, Chicago, Ill. Proceedings.

(*c*) STATE.

Arkansas Society of Engineers, Architects and Surveyors, Little Rock, Ark. Occasional papers.

Connecticut Association of Civil Engineers and Surveyors, Birmingham, Conn. Proceedings.

Illinois Society of Engineers and Surveyors, Champaign, Ill. Reports of Annual Meetings.

Indiana. Association of County Surveyors and Civil Engineers of the State of——. Rensselaer, Ind. Proceedings of Annual Meetings.

Kansas. The Civil Engineers' Association of ——, Wichita, Kan.

Ohio Society of Surveyors and Civil Engineers, Massillon, Ohio. Annual Reports.

Pennsylvania, Engineers' Society of Western——, Pittsburgh, Pa. Proceedings.

" Franklin Institute of the State of——. Journal, monthly.

(*d*) LOCAL.

Bethlehem, Pa. The Engineering Society of the Lehigh University. The Lehigh Quarterly.

* Boston Society of Civil Engineers, Boston, Mass.

Cincinnati. Engineers' Club of——.

*Cleveland, Ohio. Civil Engineers' Club of——.

Denver Society of Civil Engineers, Denver, Col.

*Kansas City, Mo. Engineers' Club of——.

Manufacturers' Club, Philadelphia. The Manufacturer, Annual Reports, etc.

Meriden Scientific Association, Meriden, Conn. Transactions, annual.

New York Academy of Sciences. Transactions.

Philadelphia. Academy of Natural Sciences.

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* These societies belong to the Association of Engineering Societies, and send us no Proceedings of their own.

Philadelphia. Fairmount Park Art Association. Annual Reports.
Philadelphia. Franklin Institute of the State of Pennsylvania. Journal, monthly.
Philadelphia. Social Science Association. Papers.
Philadelphia Yacht Club.
*St. Louis, Mo. Engineers' Club of ——.
Troy, N. Y. Rensselaer Society of Engineers. Selected papers of the ——.

Educational Institutions.

Arkansas Industrial University. Department of Engineering of ——, Fayetteville, Ark.
Columbia College, New York.
Cornell University. Ithaca, New York. Sibley College.
Lehigh University. Bethlehem, Pa. Library of ——.
Massachusetts Institute of Technology, Boston. Abstract of Proceedings of the Society of Arts, annual. Technology Quarterly.
Sibley College, Cornell University, Ithaca, N. Y.
Stevens Institute of Technology, Hoboken, N. J. The Stevens Indicator, quarterly.
University of Pennsylvania, Philadelphia. Library of ——.
U. S. Engineer School, Willetts Point, New York Harbor.
Wagner Free Institute of Science, Philadelphia. Quarterly Transactions.

Periodicals.

(*a*) daily.†

MORNING PAPERS.	EVENING PAPERS.
Philadelphia Inquirer.	Philadelphia Bulletin.
" North-American.	" Call.
" Press.	" Herald.
" Public Ledger.	" News.
" Record.	" Star.
" Times.	" Telegraph.

(*b*) weekly.

American Architect and Building News, Boston.
" Engineer, Boston.
" Gas Light Journal, New York.
" Journal of Railway Appliances, New York.
" Machinist, New York.
" Manufacturer and Iron World, Pittsburgh, Pa.
Army and Navy Journal, New York.

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*These societies belong to the Association of Engineering Societies, and send us no Proceedings of their own.

†Our Proceedings are sent to each of these Philadelphia dailies, but they are not sent to us in return.

Carpentry and Building, New York.
Coal Trade Journal, New York.
Electrical World, New York.
Engineering and Mining Journal, New York.
Engineering News, New York.
Engineering Record, New York.
Fire and Water, New York.
Iron Age, New York.
Metal Worker, New York.
Railway Age, Chicago, Ill.
Railroad Gazette, New York.
Railway Review, Chicago, Ill.
Railway World, Philadelphia.
Sanitary News, Chicago, Ill.
Scientific American, New York.

(*c*) SEMI-MONTHLY.

Black Diamond, Chicago and New York.
Mechanical News, James Leffel & Co., New York.

(*d*) MONTHLY.

American Geologist, Minneapolis, Minn.
Manufacturer and Builder, New York.
Mechanics, Philadelphia.
Power-Steam, New York.
Railroad and Engineering Journal, New York.
Street Railway Journal, New York.

LIBRARIES.

Boston Public Library. Annual Reports. Quarterly Bulletins.
Library Company of Philadelphia. Bulletin.

CANADA.

Association of Dominion Land Surveyors, Ottawa. Reports of Proceedings at Annual Meetings.
Canadian Magazine of Science and the Industrial Arts, Montreal.
Canadian Society of Civil Engineers. Transactions.
Geological and Natural History Survey of Canada. Annual Reports. Contributions to Canadian Paleontology.
Harbour Commissioners of Montreal (through Mr. John Kennedy). Annual Reports, etc.
Historical and Scientific Society of Manitoba. Annual Reports and Papers.
McGill University, Montreal.
Toronto Water Works. Annual Reports.

MISCELLANEOUS.

Club de Engenharia, Rio de Janeiro, Brazil. Revista Mensal.
El Ingeniero Civil, Buenos Aires.
Sociedad Cientifica Argentina, Buenos Aires. Annales de la ——, monthly.

FOREIGN.

GREAT BRITAIN AND IRELAND.

Societies.

Aeronautical Society of Great Britain. Annual Reports.
Institution of Civil Engineers, London. Selected Papers. (See Contributions to Library, p. 316). Abstracts of Papers in Foreign Transactions and Periodicals.
Institution of Civil Engineers of Ireland, Dublin. Transactions, annual.
Liverpool Engineering Society. Transactions and Reports.
North of England Institute of Mining and Mechanical Engineers, Newcastle-upon-Tyne. Transactions.
Society of Arts, London. Journal, weekly.
Society of Engineers, London. Transactions, annual (bound).

Periodicals.

Building News and Engineering Journal, London, weekly.
Engineering, London, weekly.
Ironmonger. The ——. Universal Engineer and Metal Trades Advertiser, London, monthly.
Railway Times, London, weekly.
Telegraphic Journal and Electrical Review, London, weekly.

Miscellaneous.

Patent Office Library, London. Abridgments of Specifications.

FRANCE.

Librairie Française, Paris. Bulletin Mensuel de la——.
Nouvelles Annales de la Construction, Paris.
Ponts et Chaussées. L'administration des ——. Paris. Annales, monthly.
Pontzen, E. Miscellaneous Publications. (See Contributions to Library.)
Société des Ingenieurs Civils. Paris. Memoires et Compte rendu des Travaux de la ——, monthly. Annuaire.

GERMANY AND AUSTRIA.

Oesterreichischer Ingenieur- und Architekten-Verein, Vienna. Wochenschrift, weekly. Zeitschrift, quarterly.
Sächsischer Ingenieur- und Architekten-Verein. Der——. Dresden. Der Civilingenieur. Eight numbers annually.
Württembergischer Verein für Baukunde, Stuttgart. Versammlungs-Berichte, annual.

PORTUGAL.

Assaciação dos Engenheiros Civis Portuguezes, Lisbon. Revista de Obras. Publicas e Minas, monthly.
O Constructor, Lisbon, monthly.

ITALY.

Ministero dei Lavori Pubblici, Rome. Giornale del Genio Civile, monthly.

SWEDEN.

Swedish Society of Engineers, Stockholm. Ingeniörs-Föreningens Förhanlingar.
Teknisk Tidskrift, Stockholm.

NORWAY.

Norwegian Society of Engineers and Architects, Kristiania. Norsk Teknisk Tidsskrift.

RUSSIA.

Imperial Technological Society, St. Petersburg.

INDIA.

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